

Management of the California State Water Project - Appendix E

1999 Water Operations in the Sacramento-San Joaquin Delta

Bulletin 132-00

May 2003



Gray Davis, Governor
State of California

Mary D. Nichols, Secretary for Resources
The Resources Agency

Thomas M. Hannigan, Director
Department of Water Resources

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FOREWORD

This is the twenty-fifth edition of Appendix E, Bulletin 132, Water Operations in the Sacramento-San Joaquin Delta, an annual publication written for the State Water Project contractors, resource agencies, the State Water Resources Control Board, and other regulatory agencies. Appendix E documents SWP operations in the Sacramento-San Joaquin Delta, in addition to reporting on Delta water quality. SWP operations are modified to meet water quality standards and flow requirements, as well as environmental and other operational constraints.

The Sacramento-San Joaquin Delta has often been called the focal point of water resources development in California's Central Valley. The Delta is the collection point for State Water Project water delivery to the San Francisco Bay Area, the San Joaquin Valley, and Southern California. Thus Appendix E is designed to document significant Delta events as well as to review overall performance of SWP Delta operations.

This report is based on the 1999 water year (October 1, 1998, through September 30, 1999), which was classified as wet for all beneficial uses under criteria set forth in the SWRCB's 1995 Bay-Delta Water Quality Control Plan.



Thomas M. Hannigan
Director

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California Water Commission

The California Water Commission serves as a policy advisory body to the Director of Water Resources on all California water resources matters. The citizen commission provides a water resources forum for the people of the State, acts as a liaison between the legislative and executive branches of State Government, and coordinates federal, State, and local water resources efforts.

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Acronyms and Abbreviations

af	acre-feet	maf	million acre feet
AFRP	Anadromous Fish Restoration Program	MWD	Metropolitan Water District of Southern California
CALFED	State and federal resource agency program coordinating Bay-Delta management activity	NBA	North Bay Aqueduct
CCWA	Central Coast Water Authority	NDOI	Net Delta Outflow Index
CCWD	Contra Costa Water District	NDWA	North Delta Water Agency
CEQA	California Environmental Quality Act	NEPA	National Environmental Policy Act
CESA	California Endangered Species Act	NMFS	National Marine Fisheries Service
cfs	cubic feet per second	PMI	Previous month's Eight River Index
CL	chloride concentration	RTM	real-time monitoring
COA	Coordinated Operation Agreement	SBA	South Bay Aqueduct
CVP	Central Valley Project	SCVWD	Santa Clara Valley Water District
CVPIA	Central Valley Project Improvement Act (PL 102-575, Title 34)	SCWA	Solano County Water Agency
D-1485	SWRCB Water Right Decision 1485	SDIP	South Delta Improvement Program
D-1630	SWRCB Water Right Decision 1630	SDBP	South Delta Temporary Barriers Project
D-1422	SWRCB Water Right Decision 1422	SEW	Suisun Marsh Ecological Workgroup
Delta	Sacramento-San Joaquin Delta	SMPA	Suisun Marsh Protection Agreement
DFG	Department of Fish and Game	SMPANT	Suisun Marsh Preservation Agreement Negotiation Team
DO	Dissolved oxygen	SMSCG	Suisun Marsh Salinity Control Gates
DOI	Delta Outflow Index	SRI	Sacramento River Index
EC	Electrical conductivity (also referred to as specific conductance)	SVUR	Sacramento Valley unimpaired runoff
EIR/EIS	Environmental impact report (State)/ environmental impact statement (federal)	SWP	State Water Project
EPA	Environmental Protection Agency	SWRCB	State Water Resources Control Board
ESA	Endangered Species Act (federal)	the Bureau	Bureau of Reclamation
FERC	Federal Energy Regulatory Commission	taf	thousand acre-feet
FRSA	Feather River Service Area	USFWS	U.S. Fish and Wildlife Service
IEP	Interagency Ecological Program	USGS	U.S. Geological Survey
ISDP	Interim South Delta Program	VAMP	Vernalis Adaptive Management Plan
		WQCP	Water Quality Control Plan
		X2	location of 2 ppt. isohaline

1. Summary

Water Supply Conditions

Water year 1999 (October 1, 1998, through September 30, 1999) was classified as wet for all beneficial uses under the State Water Resources Control Board's 1995 Bay-Delta Water Quality Control Plan criteria. This was an unprecedented fifth wet year in succession for Northern California. However, in a classic example of the La Niña weather pattern and in marked contrast to water year 1998, the southern portion of the State received relatively small amounts of precipitation from many of the winter storms.

Water Supply Allocation - Actual Deliveries

During 1999, the State Water Project delivered more than 4.09 maf of water to 27 long-term water contractors and 17 other agencies. SWP deliveries included 2.74 maf of Table A water (of which 215,937 af was delivered under the Turnback Water Pool Program), 158,070 af of Article 21 water, 4,324 af of recreation/fish and wildlife water, and 1.19 maf to satisfy water rights settlement agreements and agreements made with SWP contractors and other agencies, such as the Bureau of Reclamation.

There were no Table A water transfers between SWP long-term contractors (as permitted under the Monterey Agreement) or 1998 Table A carry-over water deliveries during 1999.

In late November 1998, the SWP water contractors were initially allocated 55 percent of 1999 delivery requests. However, due to improving water conditions and a reduction in contractor

requests, the Department was able to boost allocations to 100 percent on March 10, 1999.

State Water Project Operations

SWP Delta operations were guided in 1999 by the SWRCB's 1995 Bay-Delta Plan, adopted on May 22, 1995, and by D-1485, as amended. The 1995 Bay-Delta Plan resulted from the establishment of the 1994 State-federal Bay/Delta Accord. The Accord arose from the need for a coordinated and comprehensive ecosystem approach to management of the Bay/Delta and was designed to balance proposed SWRCB's water quality standards and federal Endangered Species Act operational criteria, with the need to provide water supply reliability. The USFWS' Delta Smelt Biological Opinion and the NMFS' Winter-run Chinook Salmon Opinion were revised on March 6 and May 17, 1995, respectively, to conform to the Bay/Delta Accord. On December 29, 1999, SWRCB adopted the Final EIR and Decision 1641 implementing the water quality objectives of the Sacramento-San Joaquin Delta Estuary and approving the petition to add points of diversion to the SWP and CVP.

The CALFED Operations Group, established by the 1994 State-Federal Framework Agreement, provided guidance to the SWP and CVP for the protection of targeted fisheries. It provided this guidance based upon information gathered from real-time fisheries monitoring to effectively implement immediate decisions on export timing, Delta Cross Channel gate operations, and temporary barrier placements. See Table 4-1 in Chapter 4 for a listing of the institutional

framework guiding SWP Delta operations during 1999.

Lake Oroville and Feather River Operations

Lake Oroville began water year 1999 with more than 2.83 maf (80 percent capacity). Inflow into the reservoir during the water year totaled about 4.9 maf, about 107 percent of average. Lake Oroville's storage peak, reflecting its water supply for the dry season, occurred on June 13, 1999, when the storage reached 3,481,157 af (98 percent of capacity). The carryover storage at the end of the water year (September 30, 1999) totaled 2.43 maf and was 105 percent of average.

Feather River Service Area contractors took water deliveries during every month of 1999 except February and March, for a total of 1.1 maf and returned a calculated 0.27 maf as agricultural runoff (24 percent of the total diversion). Releases from the Oroville-Thermalito Complex augment the flow of both the Feather and Sacramento Rivers while retention of storage reduces downstream river flow. Mean monthly river-flow was augmented during 8 months of 1999. Augmentation occurred during February and from June through December, with the highest augmentation occurring during July and August. River flow was reduced in January and from March through May, with the greatest monthly reduction occurring in April.

Delta Operations

Operation of the SWP affects the Sacramento-San Joaquin Delta in many ways, including the reduction of high winter and spring inflow, the reduction of Delta outflows by diverting water for off-stream storage, or delivery to its contractors, augmentation of Sacramento River flow and Delta outflow during the summer and early fall months, and the alteration of the natural Delta circulation and outflow pattern. During 1999, Delta water conditions, as defined under the Coordinated Operations Agreement, were in excess for the first half of the year and in balanced conditions during the latter half.

Excess flow days can be further qualified by two outflow criteria that can limit Delta export operations. These include criteria for fish salvage and another to limit export to Delta inflow ratio. A fisheries related restriction was in effect for about 69 days during 1999.

The Bay-Delta Plan sets minimum monthly San Joaquin River flow objectives at Vernalis from February through June and in part of October. The flow minimums vary with water year type and the location of the X2 geographic isohaline, at either Chipps Island or Port Chicago. All San Joaquin River flow objectives or standards were met in 1999. The Bay-Delta Plan requires the closure of the Delta Cross Channel Gates during the spring and fall, although the CALFED Operations Group allows some variations based on real-time fisheries monitoring. During 1999, the Delta Cross Channel Gates were open for 193 days, primarily from early June through late November. The gates were closed from January 1, 1999, through June 3, 1999, in response to abundant flows. On June 4, the gates were opened and remained open through November 26, when they again were closed to protect migrating salmon smolts from straying into the interior Delta. They were reopened on December 14, 1999, to help relieve Delta water quality concerns and they remained open through the end of the year.

Delta Outflow

The Bay-Delta Plan contains a calculation of Delta outflow known as the *Net Delta Outflow Index*. The plan sets minimum monthly mean NDOI standards that range between 3,000 cfs and 7,100 cfs throughout the year. Amended D-1485 requires higher NDOIs than the Bay-Delta Plan from January through June and specifies even more rigid flow minimums for the periods of April 1-14 and May 16-31. The higher flow restriction is applied during those portions of the year when both standards overlap.

All NDOI standards and objectives were met during 1999. The year's highest mean monthly NDOI occurred in February with flows that averaged 105,538 cfs; the lowest mean monthly

NDOI occurred in October with flows that averaged 4,318 cfs.

Bay-Delta Plan mean monthly flow minimums at Rio Vista are set from September through December at levels ranging from 3,000 cfs to 4,500 cfs. The amended D-1485 standards include year-round flow minimums (30-day running average) that vary from 1,000 cfs to 5,000 cfs. During compliance periods when both standards apply, the higher flow restriction is in effect. Throughout the year, Rio Vista mean monthly flow never fell below 6,205 cfs or 30-day running average flows below 5,641 cfs. All Rio Vista monthly and 30-day mean flow standards were met in 1999.

Export/Inflow Ratio. In 1999, the SWP exported 2.71 maf through Banks Pumping Plant including 60,283 af for CVP. The Bay-Delta Plan includes a year round export ratio limit on Tracy and Banks Pumping Plants, which is set as a percentage of Delta inflow. The standard for February through June can vary between 35 and

45 percent of Delta inflow, dependent upon the Eight River Index, and is set at 65 percent from July through January.

Actual exports during January 1999 averaged 14 percent when as much as 65 percent of Delta inflow may be diverted by the SWP and CVP. February through June export/inflow percentages averaged 12 percent and the ratio dropped to 9 percent during the April 17 through May 17 spring export restriction. From July through December, the percent inflow diverted restriction rises to 65 percent, although combined exports during this period averaged just 22 percent.

Amended Winter-run Chinook Salmon and Delta Smelt Biological Opinions

The amended Winter-run Chinook Salmon Biological Opinion included the concept of a warning (*yellow-light condition*) when the combined salvage at Banks and Tracy Pumping Plants rose to 1 percent of the 1998 estimated out-migrating



A view of the Delta near Walnut Grove, California

juvenile winter-run salmon population (4,548 smolts). The yellow-light condition calls for a voluntary adjustment of operations in an effort to lower salvage numbers. A salvage level of 2 percent, or 9,095 smolts, triggers a *red-light condition* and requires consultation with the Winter-run Chinook Salmon Monitoring Group.

The 1999 winter-run sized salmon restriction period ended on May 31 with the combined loss totaling 3,715 smolts, which did not result in any export restrictions.

The amended Delta Smelt Biological Opinion limits the combined incidental take of Delta smelt at the pumps of the SWP and CVP. The combined yellow-light limit of 400 Delta smelt is imposed year-round and is based on a 14-day running average of daily salvage.

Following the spring pulse flow period, combined exports were increased to 4,000 cfs on May 19. On that same day, Delta smelt salvage reached the yellow-light level of concern and exceeded the red-light level of 9,769 smelt on May 20, 1999. Exports were reduced for the balance of May, but Delta smelt salvage exceeded the red-light level more than 6-fold by the end of May. Exports were also affected in June, as Delta smelt salvage reached seven times the red-light level by month's end. Salvage declined in early July falling below the yellow-light level by mid-month.

Sacramento Splittail Listing

USFWS listed the Sacramento splittail as threatened under FESA on February 8, 1999. During 1999, the Department and the Bureau met with USFWS to establish a splittail incidental take statement for the operation of the SWP and CVP. The SWP and CVP kept an accurate record of splittail salvage, although no formal take limits were in place during 1999.

Impact of Chinese Mitten Crabs

During the summer of 1999, the Department and the Bureau installed devices to deter mitten

crabs from interfering with the pumping and salvage operations of the SWP and CVP. In 1999, far fewer mitten crabs arrived at the federal and State export facilities when compared to the previous year and, as a result, impacts on SWP pumping and salvage operations were not significant.

North Bay Aqueduct Operations

The North Bay Aqueduct conveys Delta water pumped at Barker Slough in the north Delta to contractors in Napa and Solano Counties. In 1999, NBA delivered 40,057 af of Table A water, of which 87 percent (34,753 af) went to Solano County Water Agency and 11 percent to Napa County Flood Control and Water Conservation District (4,550 af). About 753 af of Article 21 water was also delivered to Napa in 1999.

Delta Water Management

The Interim South Delta Program began in 1991 and during most years, ISDP installs four temporary south Delta barriers at locations on Middle River, Old River at Tracy, Old River at Head, and Grant Line Canal. The barriers are designed to improve water levels and circulation for agricultural uses in the south Delta.

The Old River at Head barrier is installed both in the spring and the fall. The spring barrier prevents outmigrating fish from straying into the inner Delta and the fall barrier prevents the straying of fish migrating upstream and helps alleviate low oxygen levels in the San Joaquin River. The Old River at Head barrier was not installed in the spring or fall of 1999 due to high flows and the request of the Department of Fish and Game not to install the fall barrier. The other three barriers, at Middle River, Old River near Tracy Pumping Plant, and Grant Line Canal, stabilize channel water levels for irrigation diversions during the agricultural season. These three barriers were installed in late May and early June, and they were all removed by October 8, 1999.

Delta Water Quality Standards

Delta water quality is primarily regulated by salinity standards measured as either electrical conductivity or chloride concentration. These measurements reflect the impact of seawater intrusion and agricultural drainage as affected by tributary inflows, reservoir releases, and exports. The 1995 Bay-Delta Plan contains additional water quality objectives for dissolved oxygen levels (6.0 mg/L) on specified stretches of the San Joaquin River. The Bay-Delta Plan also contains an estuarine habitat protection objective using EC (2.64 mS/cm) or flow criterion of 11,400 cfs or 29,200 cfs, depending on whether X2 is located at Chipps Island or Port Chicago, respectively. Also included are narrative objectives for salmon protection and for protection of brackish tidal marshes of Suisun Bay that implicitly list water quality measures.

Water quality objectives and standards are set to protect beneficial uses categorized as municipal and industrial, agricultural, and fish and wildlife. All agricultural EC standards and objectives were met at all sites during 1999. In addition, all fish and wildlife EC standards in the Delta and in the Suisun Marsh and all municipal and industrial chloride maximums were met, with the exception of the Contra Costa Pumping Plant on Rock Slough where, for 1 day, chlorides averaged 258 mg/L, exceeding the standard of 250 mg/L. This occurred during a Delta Cross Channel Gate closure and a period of low Delta inflow. The operators of the SWP and CVP decreased exports and increased reservoir releases in anticipation that some water quality standards might be exceeded during the gate closure. The gates were opened on December 14, although the water quality in parts of the Delta continued to deteriorate, exceeding the chlorides standard at Rock Slough on December 20, 1999.

The fall Old River at Head barrier was not installed in 1999 at the request of DFG and due to relatively high flows on the San Joaquin River, which were projected to minimize reverse flows past Stockton. During August through

October 1999, average San Joaquin River flows past Stockton ranged from -392 to +352 cfs. These low flows likely contributed to a DO sag (an area where DO levels are 5.0 mg/L or less) throughout most of the monitoring period. On October 25, 1999, the sag stretched from the eastern end of Rough and Ready Island in the eastern channel to Fourteen Mile Slough in the central channel and extended west to Turner Cut.

In contrast to previous years, DO concentrations did not recover to levels of more than 6.0 mg/L in the eastern and central ship channels in November and December. This was likely due to increased turbidity resulting from channel dredging and increased biochemical oxygen demand.

The estuarine habitat objective (X2), in place from February through June, can be met with a specified number of days in which average EC is 2.64 mS/cm or less at either Chipps Island or Port Chicago. The number of days specified for average EC is based on the previous month's Eight River Index (PMI). The X2 objective can also be met with flow criteria, which is measured as a 3-day running average of NDOI; 11,400 cfs for Chipps Island and 29,200 cfs for Port Chicago. During 1999, X2 compliance was attained using the 3-day running average of NDOI at Port Chicago from February through May 1999. During June, X2 was met at the more upstream Chipps Island location, accumulating the requisite number of days where EC averaged less than 2.64 mS/cm.

Channel salinity in the Suisun Marsh is managed through the operation of the Suisun Marsh Salinity Control Gates from October 1 through May 31.

During the eleventh control season (October 1, 1998, through May 31, 1999), the control gates were operated from October 1 through October 12 and from October 27 through November 12, 1998. The gates were operated intermittently during this period as part of a joint study to evaluate the use of modified

flashboards and their effect on the passage of adult salmon.

Marsh conditions were relatively fresh during the first half of 1999, making it unnecessary to operate the gates during the balance of the eleventh control season, although modified flashboards were in position through April 6, 1999.

During the twelfth control season, the gates were operated from September 1 through

November 9, 1999, to satisfy the needs of the adult salmon passage study. After completion of the study, the gates were operated from November 10 to December 31, 1999, to meet salinity standards despite the SWRCB's waiver of the standards during the 3-year salmon passage study.

All Suisun Marsh salinity standards were met during 1999.



This historic building in Courtland was once a general merchandise store. Reminders of the past can be found throughout the Delta.

2. Introduction

Appendix E reports on the SWP's operation in the Sacramento-San Joaquin Delta as affected by Lake Oroville operations, water conditions, water demand, pumping operations, and water quality standards, as well as environmental guidelines and initiatives.

The State Water Project

The SWP is a system of reservoirs, power plants, pumping plants, and aqueducts that begins in Plumas County where three reservoirs make up the project's northernmost facilities — Antelope Lake, Frenchman Lake, and Lake Davis.

Downstream from these three reservoirs is Lake Oroville, the keystone of the SWP. Lake Oroville conserves water from the Feather River watershed. Contained by Oroville Dam, the tallest earth-fill dam in the Western Hemisphere, Lake Oroville is the project's largest storage facility, with a capacity of more than 3.5 maf. The map of the SWP (Figure 2-1) identifies the major features of the SWP.

Water released from Lake Oroville flows down the Feather River and joins the Sacramento River near the town of Verona. The Sacramento River drains the northern portion of California's great Central Valley and ultimately flows into the Sacramento-San Joaquin Delta. The SWP



Lake Perris, southeast of Los Angeles, receives more recreation visitors than any other location in the State Water Project.



Figure 2-1. The State Water Project

and CVP, as well as local agencies, all divert water from the Delta.

Barker Slough Pumping Plant, located in the northern Delta, diverts water for delivery to Napa and Solano Counties via the North Bay Aqueduct. In the southern Delta, near Byron, the SWP diverts water into Clifton Court Forebay where Banks Pumping Plant lifts water for delivery into Bethany Reservoir. The South Bay Pumping Plant, located at Bethany Reservoir, delivers water through the South Bay Aqueduct to supply Alameda and Santa Clara Counties. Most of the water delivered into Bethany Reservoir from Banks Pumping Plant flows into the California Aqueduct for delivery to points south.

The 660-mile California Aqueduct winds along the west side of the San Joaquin Valley and transports water to O'Neill Forebay and San Luis Reservoir. The Department and the Bureau of Reclamation jointly utilize the 2-maf San Luis Reservoir, which stores both SWP and CVP water.

SWP and CVP water released from San Luis Reservoir continues to flow south through the San Luis Canal. As the water flows through the San Joaquin Valley, it has to be raised more than 1,000 feet by four pumping plants before reaching the foot of the Tehachapi Mountains.

In the San Joaquin Valley near Kettleman City, the original Coastal Aqueduct stub serves agricultural areas west of the California Aqueduct.

This branch has undergone an extension project to serve municipal and industrial water users in San Luis Obispo and Santa Barbara Counties.

The remaining water conveyed by the California Aqueduct is delivered to Southern California, but it must first cross the Tehachapi Mountains. Edmonston Pumping Plant, located at the foot of these mountains, raises the water 1,926 feet — the highest single lift of any pumping plant in the world. The water then flows into Antelope Valley, where the California Aqueduct divides into two branches — the East Branch and the West Branch.

The East Branch carries water through Antelope Valley into Silverwood Lake, located in the San Bernardino Mountains. From Silverwood Lake, the water continues flowing down the East Branch to Lake Perris, the southernmost SWP reservoir. The East Branch is currently being extended and will eventually carry water from Devil Canyon Power Plant Afterbay to Cherry Valley, bringing water to Yucaipa, Calimesa, Beaumont, Banning, and other communities. Phase I is scheduled for completion in 2001, while Phase II is expected to be completed in 2015.

Water in the West Branch of the California Aqueduct flows through Warne Power Plant into Pyramid Lake in Los Angeles County; from there it flows through the Los Angeles Tunnel and Castaic Power Plant into Castaic Lake, the terminus of the West Branch.

3. Water Supply, Allocation, and Delivery

Precipitation and Runoff

Water year 1999 (October 1, 1998, through September 30, 1999) was the fifth successive wet year for Northern California, a phenomenon that is unprecedented in the records of this century. Although the water year got off to a somewhat dry start in October 1998, a very wet November and plentiful storms during the latter half of January through February 1999 boosted northern Sierra precipitation well above average. However, in a classic example of the La Niña weather pattern and a marked contrast from water year 1998, the southern portion of the State received relatively small amounts of precipitation from many of the winter storms.

The northern Sierra Nevada is the main source of the State's surface water supply and its rainfall is indexed by averaging rain gauge totals at eight representative regional stations (8-Station Index). Northern Sierra rainfall during water year 1999 amounted to 110 percent of average, substantially less than water year 1998's bountiful 165 percent of average. Statewide rainfall amounted to 95 percent of average compared to 170 percent of average during water year 1998.

Sacramento Valley unimpaired runoff in the 1999 water year was 21.2 maf (117 percent of average) and the San Joaquin Valley unimpaired runoff was 5.91 maf, which represents 104 percent of average.

October started the water year in the northern Sierra with below-normal precipitation while November's precipitation totaled 201 percent of

average. December began wet, then turned cold and dry, with northern Sierra precipitation averaging only 56 percent. The dry spell continued into the first half of January. A pronounced precipitation gradient had become established in California, with the northern State receiving above average quantities of rainfall and Southern California receiving below average amounts.

The latter half of January 1999 provided much more precipitation, boosting the month's northern Sierra accumulation to 110 percent. In fact, January 15 began a 5-week period in which the precipitation index of the eight northern Sierra stations actually doubled, making February the most productive month of water year 1998-99. March precipitation was below normal, but included a welcomed rainstorm in the dry southern portion of the State. The first half of April produced cool, widespread showers, boosting southern California's seasonal precipitation to about two-thirds of normal. Although April's statewide precipitation was well above normal, the northern Sierra received only about 80 percent of average for the month.

May began with a few days of wet weather but most of the month was relatively dry and cool, producing a mere 44 percent of average precipitation in the northern Sierra. The first week of June provided some welcome precipitation and the showers were somewhat heavier in the central and southern Sierra. The balance of June was relatively cool and dry and the northern Sierra ended the month with only 54 percent of the average monthly precipitation.

July and August were characteristically dry. The end of the water year was quite dry as September northern Sierra rainfall amounted to only 9 percent of average (0.08 inches).

Snowpack

On average, the April to July runoff from the snowpack of the western slope of the Sierra Nevada-Cascade Range produces approximately 40 percent of California's annual usable water supply. Snowpack water content is reported in monthly Department snow survey bulletins beginning on February 1 and ending May 1. These measurements are used to predict the seasonal snowmelt runoff, known as the *April-July forecast*. The forecast for the Sacramento Basin April through July runoff represents natural flow conditions (unaltered by upstream diversions) that would occur in the absence of constructed dams. The Sacramento Basin *April-July forecast* for runoff was reported on May 1 as 121 percent of average (7.9 maf) and the observed April-July runoff totaled 111 percent average (7.3 maf). The San Joaquin River

Basin *April-July forecast* on May 1 was 99 percent of average (3.7 maf), while the observed April-July runoff totaled 104 percent of average (3.9 maf).

Historically, the April 1 snowpack water content reveals the April-July snowpack at or near its peak and is the most important predictor of seasonal snowmelt runoff. The 1999 statewide April 1 snowpack was 110 percent of average; however, cool, widespread weather systems arrived in early April, causing additional snowpack accumulation 12 days beyond April 1. In mid-April, above-average temperatures gave a zealous start to the snowmelt. Nevertheless, on May 1, 1999, the snowpack still stood at 120 percent of average for that date. May was cool and dry with the exception of some showers during the first few days of the month. June was also cool and dryer than average. Most of the snowpack was gone by the end of June, with peak snowmelt having occurred in late May. By comparison, on July 1, 1998, the slow-melting snowpack still measured 25 percent of the April 1 accumulation.



Snowpack is an important component of the State's water supply. The snowpack water content is reported monthly in the Department's snow survey bulletins from February through May.

Reservoir Storage

At the beginning of water year 1999 (October 1, 1998), the carryover storage in the State's 155 major reservoirs was near maximum at 29.7 maf (137 percent of average) — about 7.0 maf more than the previous water year's start. At the same time, the major reservoirs of the SWP (Oroville, San Luis, and the combined southern reservoirs) held 4.4 maf, about 1.2 maf more than the 1998 water year's start. Lake Oroville, the SWP's largest storage facility, held about 2.8 maf, which is about 700 taf more than last water year's start and about 123 percent of average.

By January 31, 1999, the major SWP reservoirs had increased slightly to about 4.5 maf compared to 4.4 one year earlier. Lake Oroville storage dipped slightly, about 60 taf, due to flood control limitations. The State's share of San Luis Reservoir stood at 1.10 maf compared to about 1.07 maf at the end of January 1998.

With accumulated precipitation in the northern Sierra running above average each month from January through May, the State's reservoirs amassed respectable storage levels. On May 31, 1999, the State's 155 major reservoirs contained about 33 maf, 115 percent of average and about 0.4 maf more than at this time in 1998. At the same time, the major SWP reservoirs held about 5 maf (114 percent of average) compared with about 5.07 maf on May 31 of last year. May 31, 1999, storage at Lake Oroville was about 3.45 maf compared to 3.30 maf at the same time last year. Lake Oroville reached peak storage on June 13, 1999, at 3,481,007 af, or 98.4 percent of designed storage capacity. This storage peak represents the water storage for planned releases later in the year. On May 31, 1999, the State's share at San Luis Reservoir stood at 863,254 af compared with 1.06 maf at this date the previous year.

At the end of the 1999 water year (September 30, 1999), the State's 155 major reservoirs held about 25.6 maf (118 percent of average) compared to the end of water year 1998's (September 30, 1998) 29.6 maf. The SWP's major

reservoirs contained about 3.78 maf in comparison to 4.39 maf at this time last year and Lake Oroville contained about 2.4 maf (104 percent of average) compared to 2.8 at water year 1998's end.

Water Supply Forecast Indices

Sacramento Valley

The 1995 Bay-Delta Plan contains a water supply forecast tool called the Sacramento Valley 40-30-30 Index which is used in the water budget operations studies as an indicator of available water supply. This index largely replaced its predecessor, the Sacramento River Index. SWRCB uses the Sacramento Valley 40-30-30 Index for classifying types of water years and establishing a corresponding level of protection for the Sacramento-San Joaquin Delta (Figure 3-1). The water year classification system also provides relative estimates of the potential water supply originating in a basin from rainfall and snowmelt runoff, ground-water accretion, and reservoir carryover storage.

The Sacramento Valley 40-30-30 Index incorporates seasonal differences in water contribution for the year and includes the prior year's conditions to establish a more reliable index of water available. The factors (40-30-30) represent the weighted percentages of, respectively:

- (1) the observed or forecast current year's April through July Sacramento Valley unimpaired runoff;
- (2) the observed or forecast current year's October through March Sacramento Valley unimpaired runoff; and
- (3) the previous year's index with a cap of 10. The Sacramento Valley unimpaired runoff sums the major flows into the Sacramento River Basin and is also known as the Sacramento River Index. The Sacramento Valley unimpaired runoff for water year 1999 was 21.2 maf (117 percent of average).

Year classification shall be determined by computation of the following equation:

$$\text{INDEX} = 0.4 * X + 0.3 * Y + 0.3 * Z$$

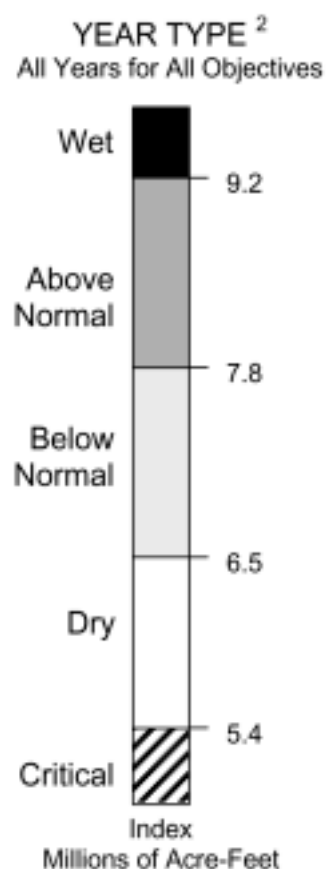
Where: X = Current year's April – July
Sacramento Valley unimpaired runoff

Y = Current October – March
Sacramento Valley unimpaired runoff

Z = Previous year's index¹

The Sacramento Valley unimpaired runoff for the current water year (October 1 of the preceding calendar year through September 30 of the current calendar year), as published in California Department of Water Resources Bulletin 120, is a forecast of the sum of the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; American River, total inflow to Folsom Reservoir. Preliminary determinations of year classification shall be made in February, March, and April with final determination in May. These preliminary determinations shall be based on hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the water year.

<u>Classification</u>	<u>Index</u> <u>Millions of Acre-Feet (MAF)</u>
Wet	Equal to or greater than 9.2
Above Normal	Greater than 7.8 and less than 9.2
Below Normal	Equal to or less than 7.8 and greater than 6.5
Dry	Equal to or less than 6.5 and greater than 5.4
Critical	Equal to or less than 5.4



¹ A cap of 10.0 MAF is put on the previous year's index (Z) to account for required flood control reservoir releases during wet years.

² The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available.

Figure 3-1. Sacramento Valley Water Year Hydrologic Classification

The Sacramento Valley 40-30-30 Water Year Classification Index was 9.8, resulting in the 1998-99 water year classification of *wet* for all beneficial uses (Table 3-1).

San Joaquin Valley

The 1995 Bay-Delta Plan also calculates a San Joaquin River Valley 60-20-20 Water Year Classification Index, which is calculated using similar methods used in the Sacramento Valley 40-30-30 Index (Figure 3-2). The San Joaquin Valley 60-20-20 Index at the 75 percent exceedence level determines the water year type for the 1995 Bay-Delta Plan's Vernalis flow standards. The Sacramento Valley unimpaired runoff and a similar San Joaquin Valley unimpaired runoff total are summed to produce the Eight River Index. This index is used to determine the duration of the 1995 Bay-Delta Plan's habitat protection standard at Chipps Island and, under specific conditions, at Port Chicago, from February through June. The San Joaquin River unimpaired runoff for the 1999 water year (including the Stanislaus, Tuolumne, Merced, and upper San Joaquin Rivers) was 5.9 maf, 99 percent of average. The San Joaquin Valley 60-20-20 Index for the 1999 water year was 3.6, resulting in the classification of above normal.

1999 Water Budget Process and Project Delivery Allocation

Water Budget Process

The SWP continues to satisfy contractors' annual water requests within contractual agreements while assuring sufficient carryover storage to meet deliveries for Delta protection and emergencies that may occur in the following year. A balance between the State's water resources and contractor demand is met through the Water Budget Process.

Delivery Allocations

The Water Budget Process makes annual forecasts based upon the following:

- (1) reservoir capacity and storage at Lake Oroville, San Luis Reservoir, Lake Del Valle, and the four southern reservoirs;
- (2) hydrology projections for the current year and future precipitation, runoff and ground water accretion (40-30-30 Index);
- (3) operational constraints for environmental protection, recreation/fish and wildlife; and
- (4) demands from contractors for agricultural,

Table 3-1. Sacramento Valley 40-30-30 Water Year Classification Index, Forecast and Actual Runoff, during the 1998-99 Water Year (maf)

Date of Forecast	Sacramento Valley 40-30-30 Index Probable Exceedence%			Water Year Classification ^a	State Water Contractor Allocated Entitlement Delivery (% of Request) ^b
	50%	90%	99%		
December 1, 1998	9.4	7.0		wet	55%
January 1, 1999	8.8		6.1	above normal	55%
February 1	8.8		6.6	above normal	60%
March 1	10.3		8.6	wet	100%
April 1	10.1		9.1	wet	100%
May 1	10.0		9.5	wet	100%
Actual water year unimpaired runoff	21.2 maf (117% of average)				
April-July forecast snowmelt runoff					
May 1 forecast	7.9 maf (121% of average)				
Actual unimpaired snowmelt runoff	7.3 maf (111% of average)				

^aProbability exceedence at the median level (50%) is used to determine Bay-Delta Plan water year class.

^bProbability exceedence at the 90% level is used to forecast SWP water supply allocations in December and thereafter the 99% level is used.

Year classification shall be determined by computation of the following equation:

$$\text{INDEX} = 0.6 * X + 0.2 * Y + 0.2 * Z$$

Where: X = Current year's April – July
San Joaquin Valley unimpaired runoff

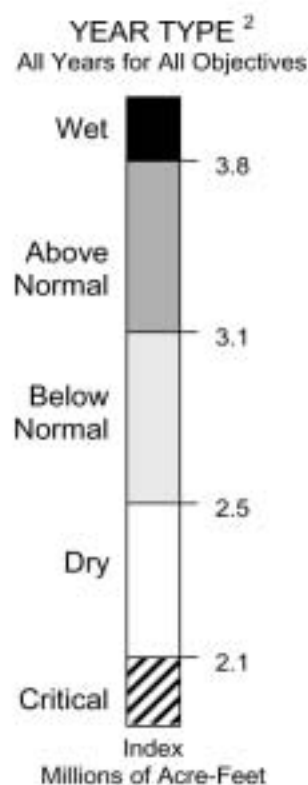
Y = Current October – March
San Joaquin Valley unimpaired runoff

Z = Previous year's index¹

The San Joaquin Valley unimpaired runoff for the current water year (October 1 of the preceding calendar year through September 30 of the current calendar year), as published in California Department of Water Resources Bulletin 120, is a forecast of the sum of the

following locations: Stanislaus River, total flow to New Melones Reservoir; Tuolumne River, total inflow to Don Pedro Reservoir; Merced River, total flow to Exchequer Reservoir; San Joaquin River, total inflow to Millerton Lake. Preliminary determinations of year classification shall be made in February, March, and April with final determination in May. These preliminary determinations shall be based on hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the water year.

<u>Classification</u>	<u>Index Millions of Acre-Feet (MAF)</u>
Wet	Equal to or greater than 3.8
Above Normal	Greater than 3.1 and less than 3.8
Below Normal	Equal to or less than 3.1 and greater than 2.5
Dry	Equal to or less than 2.5 and greater than 2.1
Critical	Equal to or less than 2.1



¹ A cap of 4.5 MAF is put on the previous year's index (Z) to account for required flood control reservoir releases during wet years.

² The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available.

Figure 3-2. San Joaquin Valley Water Year Hydrologic Conditions

municipal, industrial uses, and other agencies including the Bureau.

The Water Budget is an iterative water delivery allocation process. Initial allocations for the coming year are made in December and are based on operations studies that assume 90 percent exceedence of historic water supply. *Exceedence* refers to the probability that unimpaired flow will exceed the historic water supply. Forecasts for the water year are updated at least monthly using operations studies beginning in December. The final May 1 water supply forecast sets the delivery allocations for the water year.

SWP long-term water contractors were initially allocated about 55 percent of their 1999 initial delivery requests of 3.42 maf in late November 1998. On February 10, 1999, the allocation was increased to 60 percent. Improving water conditions and a reduction in the SWP contractor requests to 3.19 maf enabled the Department to boost allocations to 100 percent on March 10.

Water Deliveries

Representatives of the Department and the SWP's long-term water contractors signed the Monterey Agreement on December 1, 1994, to establish the principles for amending the Department's SWP water contracts with the long-term contractors. The Agreement updated the management of the SWP by substantially revising SWP long-term contracts and their administration. The Monterey Agreement contains 14 principles that reflect the Agreement's goals to increase reliability of existing water supplies, provide stronger financial management of the SWP, and to increase water management flexibility by providing additional tools to local water agencies. In 1999, the SWP delivered more than 4.09 maf to 27 of its 29 long-term contractors and to 17 other agencies. This amount is 1.26 taf more than the water delivered during 1998.

Annual Table A Deliveries

Annual Table A deliveries in 1999 totaled 2.74 maf. This includes 215,937 af of turnback

pool water that was delivered in 1999. There was no carryover Table A water from 1998, nor any makeup water under Article 12(d) or 14(b) delivered by the SWP in 1999. In addition, no Table A transfer water was delivered in 1999. There were, however, 158,070 af of Article 21 water and 4,324 af of water for fish/wildlife and recreation delivered in 1999. Article 21 water is a category of water that was developed as part of the Monterey Agreement.

Deliveries to Non-SWP Agencies

During 1999, the Department conveyed 60,283 af of CVP water through SWP facilities. The following agencies and corporations received water through these agreements with the Bureau: Lower Tule River Irrigation District, Pixley Irrigation District, Musco Olive Products Inc., DFG, U.S. Department of Veteran Affairs, U.S. Fish and Wildlife Service, and Westlands Water District. CVP water was also conveyed under SWRCB's WR 95-06, continued and modified by WR 98-09, and which allows the use of Banks Pumping Plant as a joint point of diversion for water supply the CVP was unable to export due to fisheries restrictions.

Water rights water is another category of water transported through SWP facilities to long-term SWP contractors and other agencies according to terms of various local water rights agreements. In 1999, 1,108,672 af of water in this category was delivered to the Feather River, South Bay, and Southern California areas.

Floodwater

Occasionally, during wet years, the Department accepts floodwater from the Kern River into the California Aqueduct through the Kern River Intertie — for delivery to water agencies under agreements or to help satisfy SWP delivery demands downstream of the Intertie. This operation helps to alleviate flooding of farmlands within the Kern River Interests service and surrounding areas. During 1999, the Department did not accept any floodwater through the Kern River Intertie into the California Aqueduct.

4. State Water Project Operations

The water operations data used in this report are preliminary and may not agree exactly with final figures; however, they are appropriate for use in this report. References to years are calendar years, except where noted.

State Water Project Operational Criteria

The Sacramento-San Joaquin Delta is an estuary and a navigable waterway subject to many State and federal laws that are designed to protect water quality, wetlands, anadromous and native fisheries, and migratory birds, in addition to threatened and endangered species. Table 4-1 lists the agreements, decisions, opinions, and rules that make up the institutional framework for SWP operations in the Sacramento-San Joaquin Delta. These operational criteria, in combination, have a significant impact on water diversion from the Sacramento-San Joaquin Delta. With the exception of newly adopted criteria, the operational criteria will not be described further in this report. For additional information on these criteria, please refer to Bulletin 132-99 Appendix E.

On December 29, 1999, SWRCB adopted the final EIR and Decision 1641 implementing the water quality objectives of the Sacramento-San Joaquin Delta Estuary and approving the petition to add points of diversion to the SWP and CVP. Though the hearings are still in progress, D-1641 replaces D-1485 as modified by Water Right Order 98-09 and conditions the water rights permits of the SWP and CVP to implement the objectives of the SWRCB's 1995 Bay-Delta Water Quality Control Plan. D-1641 covers

Phases 1-7 of the Bay-Delta Water Rights Hearings, leaving Phase 8, the allocation of responsibility for meeting the Delta outflow objectives, to be considered in 2000 or 2001.

Feather River Water Operations

Water stored in Lake Oroville (Figure 4-1) is released through Hyatt Power Plant into the Thermalito Diversion Pool, and then travels through the Thermalito Diversion Dam into the Thermalito Power Canal and then into the Thermalito Forebay. Water is released for electrical generation at the Thermalito Pumping-Generating Plant and then passes into the Thermalito Afterbay. It is released to several local distribution systems for use in the Feather River Service Area or passes out to the Feather River through the Thermalito Afterbay River Outlet.

Lake Oroville releases are routinely made for flood control, water supply, fish and wildlife protection, Delta water quality needs, and in response to unusual operational events. The 1983 Feather River Agreement with DFG sets minimum water flow rates and specifies maximum temperatures on the low flow channel of the Feather River.

Flows are also released from the Thermalito Diversion Dam to supply the low-flow channel of the Feather River; it also flows into a pipeline supplying the Feather River Fish Hatchery. The Feather River low-flow channel is the pre-SWP river channel and passes downstream of the hatchery, then merges with outflow from the Thermalito Afterbay river outlet, located 8.5 miles down river from the diversion dam.

Table 4-1. Institutional Framework for SWP Operations in the Sacramento-San Joaquin Delta during 1999

-
- Agreement between DWR and DFG "Concerning Operations of the Oroville Division of the SWP for the Management of Fish and Wildlife" - 7/67 and 8/83
 - WRCB Water Right Decision 1485 - 8/78 Modified by SWRCB Order 92-02 and SWRCB Order 92-08
 - Corps of Engineer's Section 10 permit and Public Notice 5820-A 10/81. Permitted operations of Banks Delta Pumping Plant.
 - Agreement between the United States of America and State of California for Coordinated Operation of CVP and the SWP (COA) - 1986
 - Agreement between DWR and DFG to offset direct fish losses in relation to the H.O. Banks Delta Pumping Plant, (Four Pumps Agreement) - 12/86
 - Suisun Marsh Preservation Agreement Among USBR, DWR, DFG, and SRCD - 3/87
 - Central Valley Project Improvement Act (PL 102-575, Title 34) or CVPIA - 9/92
 - NMFS Biological Opinion for Winter-run Salmon, long-term, 2/93. Amended 5/95 to conform to Bay/Delta Accord
 - USFWS Formal Consultation on the 1994 Operation of the CVP and SWP: Effects on Delta Smelt (Long-term Biological Opinion) - 1/94, amended 3/95 to conform to the Bay/Delta Accord
 - Framework Agreement between the Governor's Water Policy Council of the State of California and the Federal Ecosystem Directorate - 6/94
 - Monterey Agreement - Statement of Principles by the State Water Contractors and the State of California Department of Water Resources for Potential Amendments to the State Water Supply Contracts - 12/94
 - Principles For Agreement On Bay-Delta Standards Between The State Of California and The Federal Government (Bay-Delta Accord) - 12/94
 - Formal Consultation and Conference on Effects of Long-Term Operation of the Central Valley Project and State Water Project on the Threatened Delta Smelt, Delta Smelt Critical Habitat, and Proposed Threatened Sacramento Splittail, U.S. Fish and Wildlife Service - 3/95
 - Water Quality Control Plan for the San Francisco Bay /Sacramento-San Joaquin Estuary (1995 Bay-Delta Plan) - 5/95
 - Water Right Order 95-06 Regarding Petition for Changes in Water Rights That Authorize Diversion and Use of Waters Affecting the San Francisco Bay/Sacramento-San Joaquin Delta Estuary - 6/95
 - Water Right Order 95-12 Order Validating the Issuance of Conditional Temporary Urgency Change Order Adding a Point of Re-diversion - 7/95
 - Principles For Agreement On Bay-Delta Standards Between The State Of California And The Federal Government (Bay-Delta Accord) extended for 1 year -12/97
 - Water Right Order 98-09 Interim order that continues, as modified, the temporary terms and conditions set forth in WR 95-06 -12/98
-

Lake Oroville operations alter seasonal flows in the Feather River and subsequently in the Sacramento River and the Sacramento-San Joaquin Delta by retaining a portion of the winter and spring runoff for release during the summer and fall. Flood control operations at Lake Oroville occur from October through June and help dampen extreme flood peaks, thereby moderating Delta inflows (Table 4-2).

The Department and the Bureau proportionally meet Sacramento Basin and Delta water needs through SWP and CVP operations as specified in the 1986 COA. The application of COA opera-

tional measures is conditioned by flows into the Delta. Operations of both projects seek to balance exports with in-basin and fish and wildlife needs. Excess conditions allow greater flexibility in project operations; however, operations can be restricted during excess periods. A fish-related restriction applies when export pumping may impact endangered or threatened Delta fisheries. Exports are also restricted during excess flows to balance the export/inflow ratios within set objectives. A fisheries-related restriction was in effect during approximately 19 percent of the designated "excess" outflow days (69 days) during 1999.

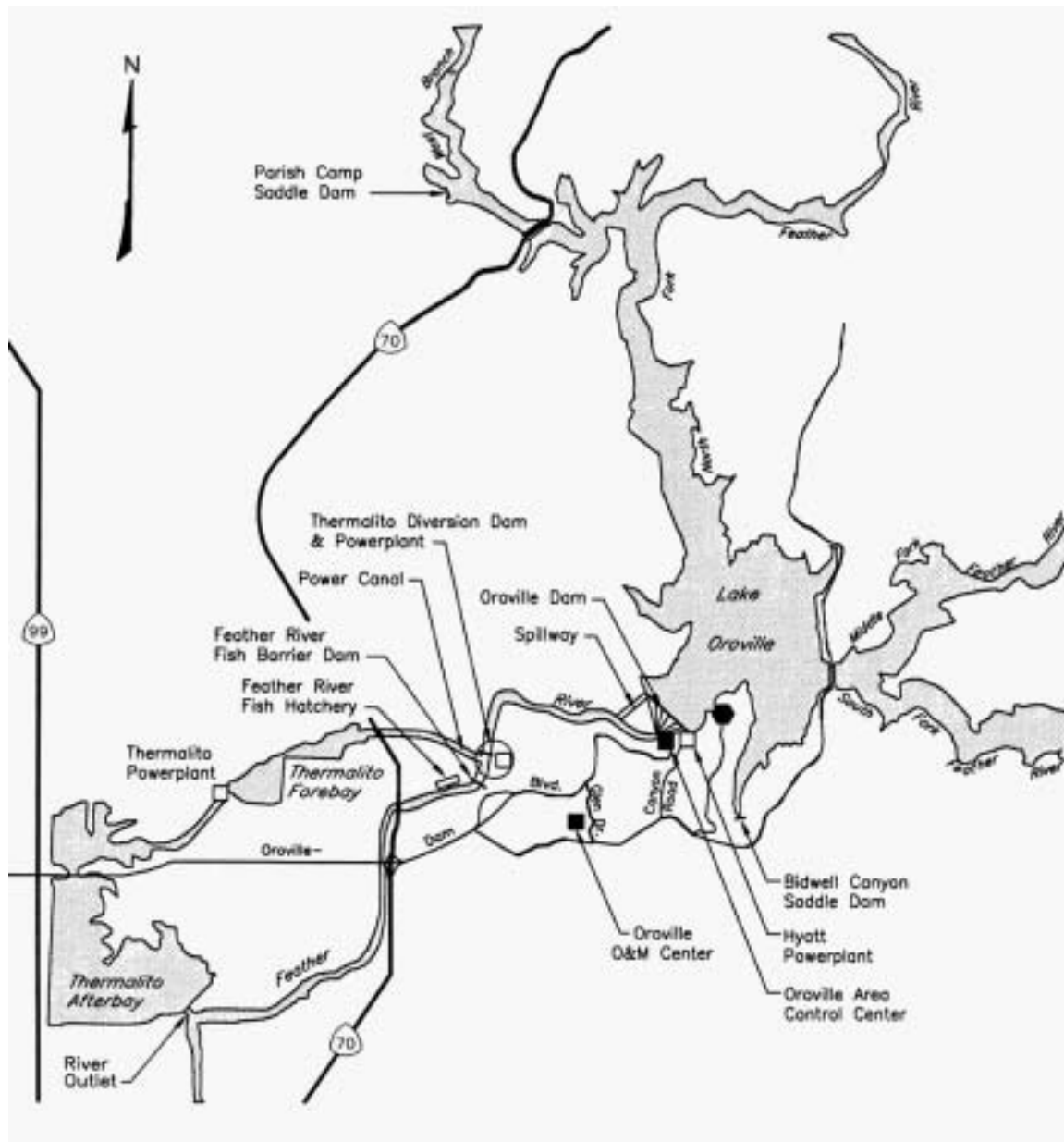


Figure 4-1. A map of the Oroville-Thermalito Complex

In 1999, sustained excess outflow conditions, as defined by COA, predominated for the first half of the year; however, operations were restricted to protect fish from April 17 to June 24. On June 25, the SWP and CVP entered into balanced conditions. The projects remained in balanced conditions through the end of the year, with the exception of a 30-day period of excess conditions that began on November 9.

Lake Oroville Inflow, Releases, and Storage

Lake Oroville began water year 1999 (October 1, 1998) with storage at 2.83 maf, which is about 80 percent capacity and 122 percent of average. This start of water year storage represents about 700 taf more than at this point in the 1998 water year. Lake Oroville inflow for the 1999 calendar year was 4.49 maf, somewhat less than water

year's total of 4.94 maf, 107 percent of average. Though November was wet, October and December 1998 received only about half of the monthly average precipitation and higher winter inflows into Lake Oroville did not begin until about January 18, 1999. January's inflow totaled 515 taf, while February and March received 905 taf and 713 taf, respectively. Inflows decreased somewhat after March, with April inflows totaling 564 taf and May inflows remaining steady at 545 taf. During June, inflows showed a marked decrease totaling 272 taf.

During mid-March, storage at Lake Oroville began a gradual increase that continued until it peaked on June 13, 1999, at 3,481,157 af — about 98 percent capacity. February contained the highest total monthly inflow, with more than 905 taf for the month, and the highest mean daily inflow rate, with 54,706 cfs on February 9. Immediately following Lake Oroville's June 13

storage peak, storage began a slow, steady decline that, for the most part, continued through the end of the calendar year. September held the lowest monthly inflow rate, averaging only 1,740 cfs per day, while October had the lowest daily inflow rate of 1999, averaging only 542 cfs on October 24. Lake Oroville's carryover storage at the water year's end, September 30, 1999, was 2.43 maf, 105 percent of average (Figure 4-2 and Table 4-3). All Feather River flow and temperature criteria set in the 1983 DFG Feather River Agreement with the Department were met in 1999.

Feather River Service Area Diversions

Diversions are made to FRSA from the Oroville-Thermalito Complex to local water agencies and to satisfy water rights settlements that predate the construction of the SWP.

Table 4-2. Monthly Summary of the Oroville-Thermalito Complex Operations during 1999 (cfs)

Lake Oroville Inflow				Below Thermalito Outlet						Feather River Service Area	
Month				With SWP			Without SWP			Mean Diversion	Mean Daily Return Flow
	Average	Low Daily	High Daily	Average	Low Daily	High Daily	Average	Low Daily	High Daily		
Jan	8,375	2,664	28,438	7,004	2,045	14,000	8,088	2,001	28,438	372	86
Feb	16,301	6,010	54,706	16,142	7,000	25,000	16,301	6,010	54,706	0	0
Mar	11,598	8,136	24,958	9,074	3,000	20,001	11,598	8,136	24,958	0	0
April	9,493	6,807	14,965	4,154	3,000	5,585	9,175	6,807	13,741	422	104
May	8,870	6,837	11,017	3,720	2,406	5,783	6,702	4,925	9,055	3,008	841
June	4,563	2,875	6,281	3,062	2,319	8,127	2,403	503	4,397	2,611	445
July	2,857	1,827	4,237	9,172	8,365	9,860	503	219	1,484	3,025	373
Aug	2,916	1,224	3,948	5,567	3,457	9,003	884	333	1,924	2,617	527
Sept	1,737	1,049	2,506	3,921	3,044	4,841	1,374	728	2,133	1,134	754
Oct	2,234	512	5,030	3,719	2,809	5,072	1,669	287	4,289	1,264	674
Nov	3,441	1,965	5,376	2,784	2,589	2,863	2,313	712	4,387	1,465	337
Dec	2,863	1,570	4,163	3,401	2,541	3,776	1,949	696	3,182	1,188	273

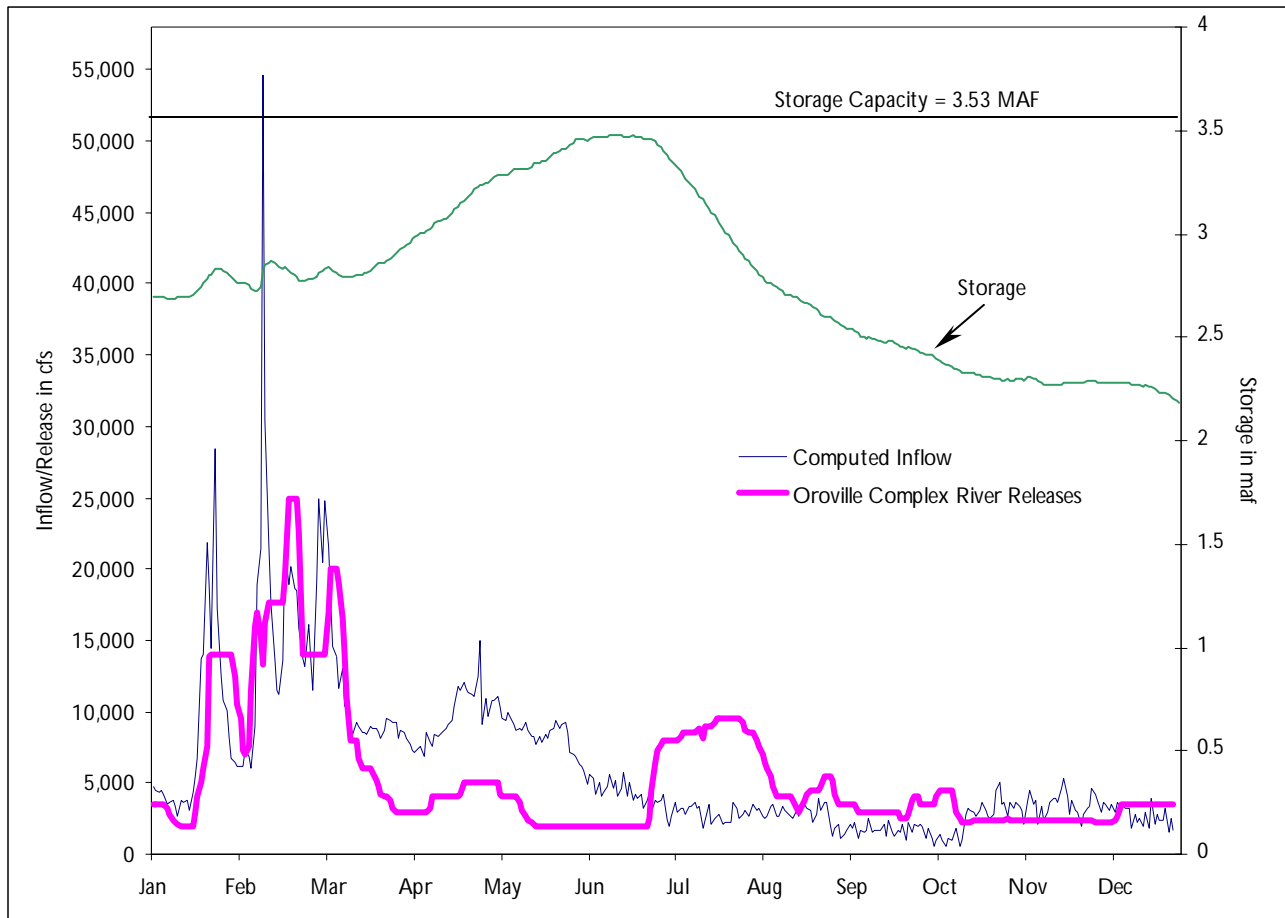


Figure 4-2. Lake Oroville inflow, releases, and storage during 1999

Table 4-3. Lake Oroville Storage during Water Year 1998-99

Date	maf	Percent of Capacity ^a	Percent of Historic Average
October 1, 1998	2.83	80	122
February 1, 1999	2.77	78	114
March 1, 1999	2.79	79	108
April 1, 1999	2.94	83	104
May 1, 1999	3.25	92	110
WY peak on June 29 ^b	3.48	98	117
September 30, 1999	2.43	69	105

^aLake Oroville has a capacity of 3,537,580 af

^bPeak daily storage during Water Year 1999 equaled 3,481,157 af

The 1999 FRSA diversions totaled 1.11 maf and occurred during all months except February and March. FRSA returns water to the Feather River in the form of agricultural runoff and in 1999 the calculated return totaled 0.27 maf, or about 24 percent of the total diversion. The largest diversions occurred from May to August.

Effects of the Oroville-Thermalito Complex Water Operations on Feather and Sacramento River Flow

Water releases from the Oroville-Thermalito Complex impacts both the Feather and Sacramento Rivers, although the effect on Sacramento River flow (below Freeport) is delayed by about a 2-day travel time.

The Department computes a *with SWP* (current project) and *without SWP* (pre-project) flow to describe the effects of Oroville-Thermalito Complex operation on both rivers. Reservoir evaporative water losses are not included in these computations. They are defined as follows:

- (1) The sum of Oroville-Thermalito Complex releases to the Feather River plus the estimated FRSA return flows defines the *with SWP* flow.
- (2) The pre-project *without SWP* flow is calculated as Lake Oroville inflow minus deliveries to FRSA (up to the limit of inflow), plus return flows from FRSA.
- (3) The difference between the *with SWP* and *without SWP* flows is the approximated effect of SWP operations on Feather River flows.

Currently, most diversions to FRSA in the summer months exceed calculated pre-project Feather River flows. Under pre-project conditions *without SWP*, FRSA diversions from the Feather River could not have exceeded river flow. As a result, the *without SWP* average monthly flow cannot be computed directly from Table 4-2 summary data.

Augmentation

Sacramento and Feather Rivers flows are considered augmented when the water released from the Oroville-Thermalito Complex exceeds the calculated pre-project flows. Feather River flows are often augmented as a result of Oroville-Thermalito releases executed for both evacuation of adequate flood control storage capacity in Lake Oroville, and to meet conditions specified in the 1983 Feather River



The Bidwell Bar Bridge spans the middle fork of Lake Oroville. It was designed by the Department and completed in August 1965.

Agreement with DFG. Lake Oroville water is also released to meet Delta water quality and flow standards, ESA criteria, as well as SWP and non-SWP export needs at Banks Pumping Plant.

During 1999, the operations of the Oroville-Thermalito Complex augmented Sacramento and Feather River flows in February and from June through December; the highest flow augmentation occurred during July and August.

Reduction

Feather and Sacramento River flows are considered reduced (designated by a negative value) when flow levels fall below pre-project conditions. Flows were reduced in 1999 by project operations during high inflow periods in January and from March through May. Monthly reductions were greatest during April (Table 4-4 and Figure 4-3).

SWP Delta Operations

The Sacramento-San Joaquin Delta is an estuary subject to sizable daily tidal fluctuations in flow and water levels. Tidal changes in the Pacific Ocean cause flow reversal twice daily throughout much of the Delta. Flow patterns can also be altered to some degree by SWP and CVP pumping. SWP's Banks Pumping Plant begins the export of Delta water from Clifton Court Forebay into the California Aqueduct and nearby South Bay Aqueduct. The federal Tracy Pumping Plant, located near Banks Pumping Plant, begins exports through CVP's Delta-Mendota Canal. The SWP also exports water in the northern Delta through its Barker Slough Pumping Plant into the North Bay Aqueduct.

Delta Cross Channel Gate Operations Criteria

Sacramento River flow at Walnut Grove in the northern Delta (between Freeport and Rio Vista) can be diminished by water diversion into the Delta Cross Channel or into Georgiana Slough, a natural channel just downstream of the Delta

Cross Channel. The Delta Cross Channel is a gated diversion channel constructed and operated by the Bureau. The Delta Cross Channel Gates are usually closed whenever Sacramento River flow at Freeport exceeds approximately 25,000 cfs, in an effort to reduce the flooding potential on the Mokelumne River and to prevent scour on the downstream side of the gate structure. However, they may be opened when Delta water quality standards cannot be reasonably met by other means.

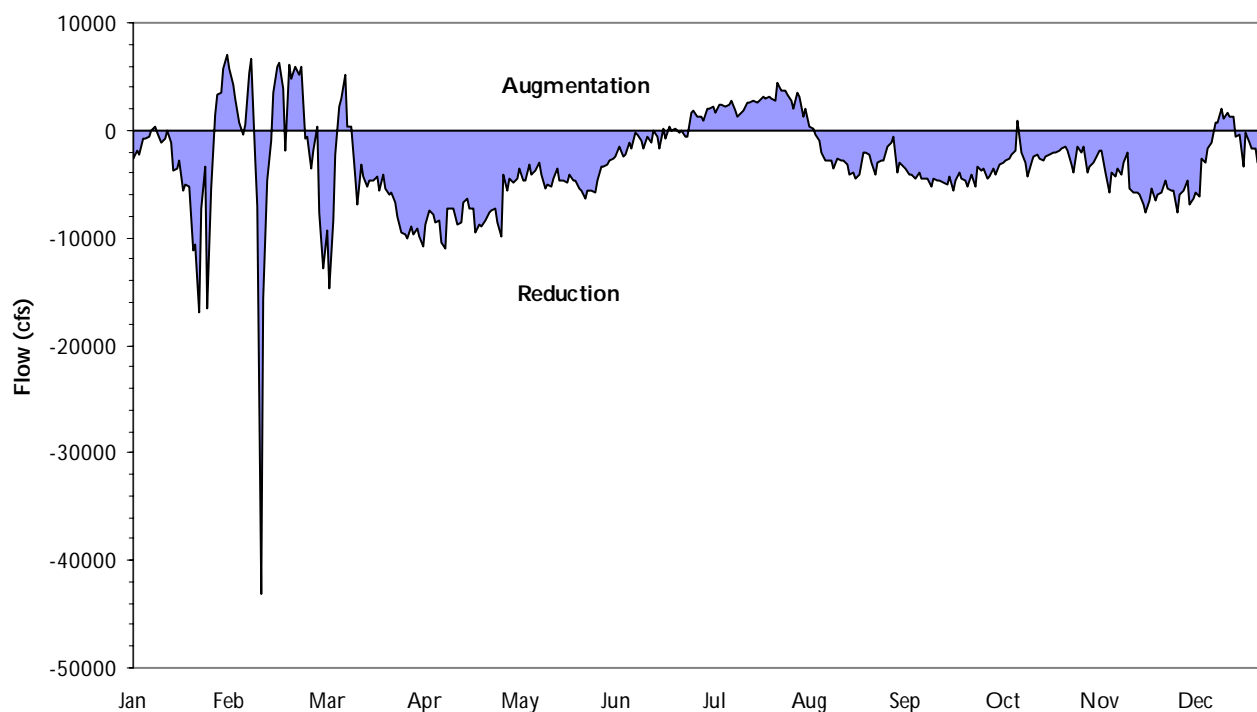
SWRCB's Bay-Delta Plan, as amended WR 95-06, calls for closure of the gates from February 1 until May 20, while from May 21 through June 15 the gates may be closed for a total of 14 days. During this period, the CALFED Operations Group determines timing and duration of gate closures. From November through January, the gates may be closed for a total of 45 days as determined by the CALFED Operations Group and based on real-time monitoring for the presence of winter-run salmon.

During 1999, the Delta Cross Channel Gates were open for 193 days (Figure 4-4). The gates were closed during January, with Freeport flows well over 25,000 cfs, and remained closed until June 3. The gates opened on June 4 and remained opened for an uninterrupted period of 176 days, closing on November 26, 1999, to protect out-migrating juvenile Chinook salmon from straying into the interior Delta. The gate closure occurred during a period of low Delta inflow and high exports at Banks and Tracy Pumping Plants, which caused a salinity increase in Delta water. Ultimately, the Delta Cross Channel Gates were reopened on December 14 to divert fresher water into the interior Delta. Despite the fact that the gates remained open through the end of the year, the chloride level at Rock Slough exceeded the SWRCB's municipal and industrial standard for chloride of 250 mg/L on December 20. Please see Chapter 5 for a complete account of this incident (Table 4-5).

Table 4-4. Effects of SWP Oroville Operations on Feather and Sacramento River Flow during 1999 (cfs)^a

	Months with Mean Augmentation				Months with Mean Reduction		
	Mean (+)	Minimum Augmentation	Maximum Augmentation		Mean (-)	Minimum Reduction	Maximum Reduction
February	307	-41,456	7,094	January	-1,455	7,280	-14,438
June	26	-2,657	5,830	March	-2,249	7,428	-10,958
July	8,561	6,727	9,599	April	-5,171	-2,549	-8,375
August	4,903	2,531	8,636	May	-3,031	-1,216	-4,814
September	2,722	1,237	5,915				
October	2,151	-897	4,711				
November	570	-1,641	2,144				
December	1,327	-1,270	3,065				

^aComparison of present river flows that would have occurred without Oroville Dam.

**Figure 4-3.** Effects of SWP operation on Feather River flow in 1999

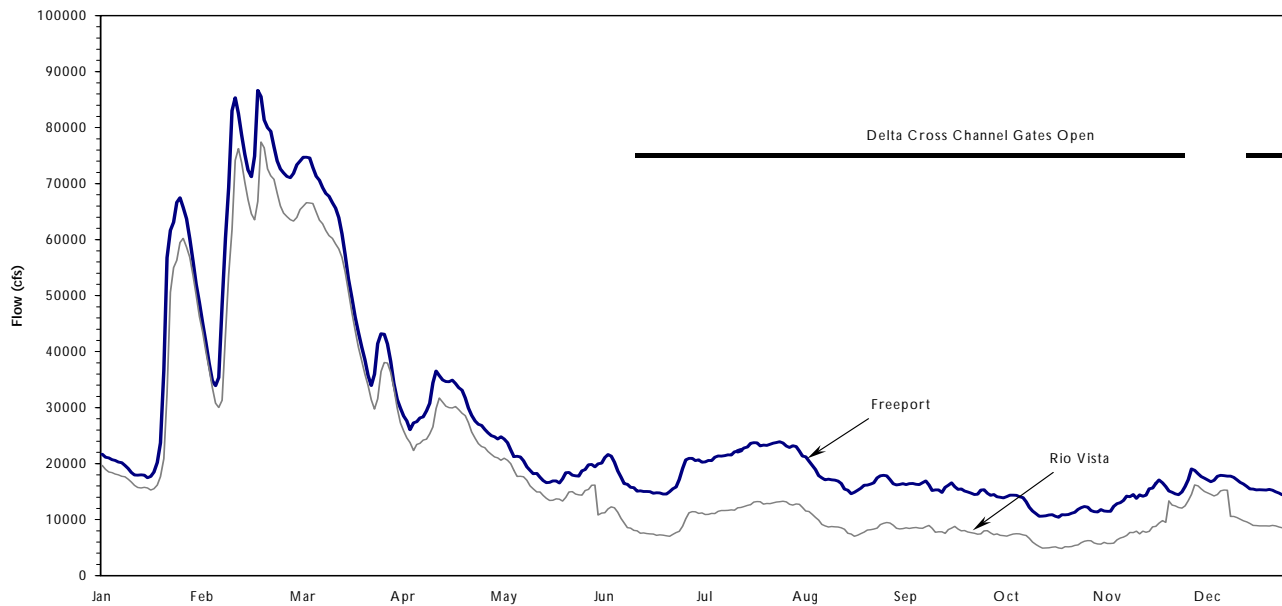


Figure 4-4. Sacramento River flows and Delta Cross Channel status during 1999

Table 4-5. Monthly Summary of Sacramento River Flows during 1999(cfs)

	At Freeport			At Rio Vista		
	Mean	Low Daily	High Daily	Mean	Low Daily	High Daily
Jan	34,547	17,495	67,454	29,837	15,283	60,213
Feb	67,149	33,925	86,652	59,154	30,013	77,401
Mar	56,853	33,934	74,727	51,378	29,743	66,590
Apr	30,644	25,517	36,545	26,793	22,174	33,522
May	19,723	16,521	24,982	16,439	13,314	21,647
Jun	17,194	14,550	21,621	9,368	7,038	16,169
Jul	22,189	20,255	23,908	12,115	10,903	13,293
Aug	17,975	14,620	23,209	9,431	7,028	12,807
Sep	15,802	14,471	17,163	8,240	7,391	9,389

Note: Flows between Freeport and Rio Vista are primarily diminished by diversions through the Delta Cross Channel Gates or through Georgiana Slough, a natural channel.

Summary of Sacramento River Flows during 1999(cfs)

10,423	14,709	6,205	4,855	8,032
11,370	17,080	8,092	5,622	13,311
14,393	19,055	11,782	8,545	16,212

and Rio Vista are primarily diminished by diversions through the Delta Cross Channel though, a natural channel.

Flow Standards

The Bay-Delta Plan sets flow rate objectives for the San Joaquin River at Vernalis, the Sacramento River at Rio Vista, and for Delta outflow using NDOI. Real-time fisheries monitoring is a tool used in determining the timing and duration of the San Joaquin River at Vernalis flow standard during April, May, and October. The 1999 Real-time Monitoring Program sampled fish 5 days per week at 14 Delta sites, from April 1 through July 5. The RTM Data Summary Team aided the CALFED Operations Group in making water project operational decisions by providing a synopsis of the monitoring results and recommendations. All flow objectives were met during 1999.

Vernalis Flow

Vernalis, located at the southernmost boundary of the Delta near the confluence of the Stanislaus and San Joaquin Rivers, represents the San Joaquin River's contribution to Delta inflow.



The Sacramento-San Joaquin Delta has more than 100 marinas and waterside resorts.

The Vernalis minimum monthly flow objective changes with water year type and is also dependant on whether the Habitat Protection Standard (X2) is met at either Chipps Island or further down-stream at Port Chicago. The San Joaquin Valley Water Year Index at the 75 percent

exceedence level determines the Vernalis water year type. During water year 1999, X2 compliance was attained at Port Chicago from February through May, requiring the higher base flow objective at Vernalis during those months. In June, X2 compliance was met at Chipps Island as a result; Vernalis flows were required to meet the lower base flow objective for June.

During wet years, a base flow minimum is set at 3,420 cfs (monthly or partial monthly average) for the San Joaquin River at Vernalis from February through April 14 and May 16 through June 30 when X2 is met at Port Chicago. An additional base flow minimum of 1,000 cfs applies during October, with the addition of 28,000 af pulse/attraction flow to bring up San Joaquin River flows to 2,000 cfs. The CALFED

Operations Group may also determine timing and duration of these flows based on real-time fisheries monitoring.

This base flow objective helps to maintain a positive outflow through the central Delta while minimizing reverse flows conditions and fish entrainment at the export pumps. The 7-day average must not be less than 20 percent of period mean. During 1999, San Joaquin River at Vernalis monthly flow averaged 10,969 cfs,

8,311 cfs, and 5,634 cfs for February, March, and the first half of April, respectively. Flows averaged 4,337 cfs during the latter half of May and were 3,154 cfs during June. October flows averaged 2,413 cfs. All Vernalis base flow requirements were met in 1999 (Table 4-6 and Figure 4-5). The Bay-Delta Plan includes a spring pulse flow objective for the San Joaquin River at Vernalis, also conditioned by San Joaquin Valley 60-20-20 Index and

Table 4-1. San Joaquin River Flow Objectives Measured at Vernalis during 1999 (cfs)

Period	Objectives and Flows	
	Monthly or Period Mean > ^a	Actual Monthly or Period Mean
Base Flow^b		
Feb	3,420 or 2,130	10,969
Mar	3,420 or 2,130	8,311
Apr 1-14	3,420 or 2,130	5,634
May 16-31	3,420 or 2,130	4,337
Jun	3,420 or 2,130	3,154
Oct ^c	2,000	2,413
Pulse Flow (waived - see AFRP criteria below)		
Apr 17 - May 17	7,020	6,914
Vernalis Adaptive Management Program Experimental Period		
VAMP provides alternate pulse flow objectives and combined export targets for the April 15-May 15 pulse flow period		
	<i>Export Limit</i>	<i>Combined Exports</i>
Apr 17 - May 17	3,400 ^d	3,263

Additional base flow criteria:

^aHigher flow objective was applied as the 2 ppt isohaline (X2) objective was west of Chipps Island.

^b7-day running average shall not be less than 20% below the flow rate objective.

^c1,000 cfs plus an additional 28,000 af pulse/attraction flow to bring up monthly average to 2,000 cfs; timing is determined by CALFED Operations Group.

^dIn 1999, high San Joaquin River flows prompted an alternate fisheries study associated with VAMP that limited combined exports to 3,000 cfs when Vernalis flows were in excess of 15,000 cfs.

the X2 compliance location. This spring pulse flow aids the transport of Delta smelt out of the southern and central Delta into Suisun Bay during their critical spawning period. However, the pulse flow's timing and duration is based on real-time fisheries monitoring to coincide with fish migration in the San Joaquin River and its tributaries.

The spring pulse flow period contained in the Bay-Delta Plan generally coincides with the Vernalis Adaptive Management Plan spring experimental period. VAMP export and flow criteria are recognized as an alternative to spring pulse flow criteria contained within the Bay-Delta Plan. In the spring of 1999, the Department and the Bureau were preparing to implement VAMP flow and export targets. However, on April 16, 1999, a Federal District Court issued a restraining order preventing the implementation of in-Delta AFRP measures. Since VAMP is an AFRP

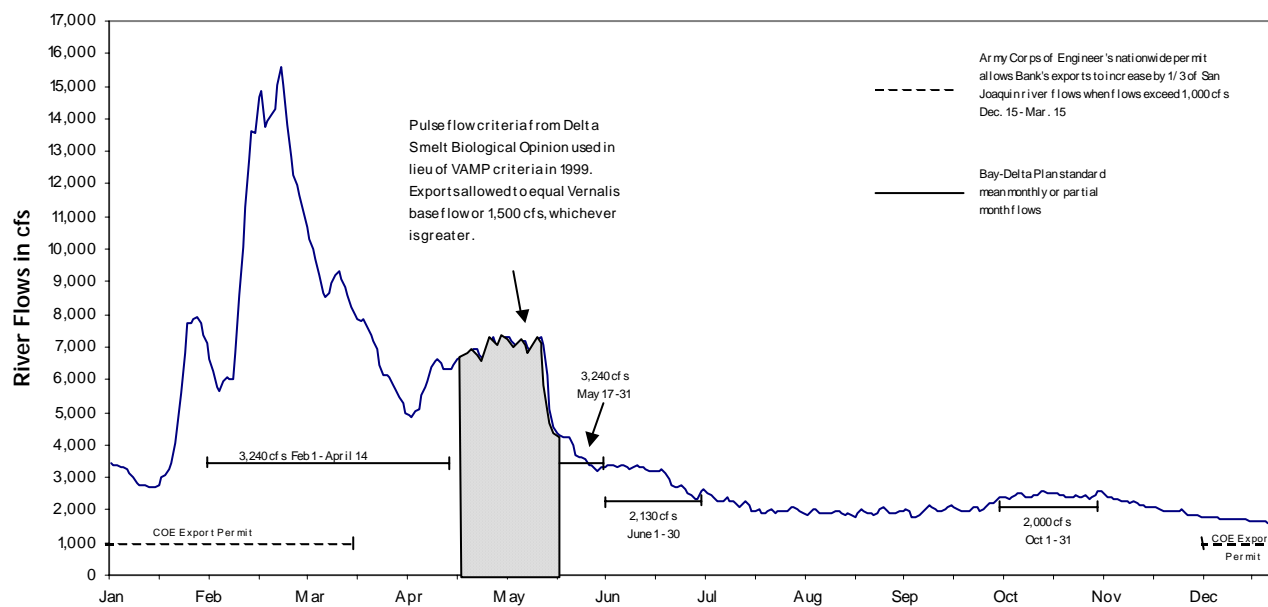


Figure 4-5. San Joaquin River flow standard and operational criteria at Vernalis in 1999

action outlined in CVPIA, the CALFED Operations Group opted to use the pulse flow criteria contained within the 1995 Delta Smelt Biological Opinion. This resulted in a flow target of

7,020 cfs, while actual flows averaged 6,914 cfs during the pulse flow period.



The Paintersville Bridge crosses the Sacramento River near Courtland, California.

Rio Vista Flow

Sacramento River flow at Rio Vista can be reduced by diversions through the Delta Cross Channel and through natural channels, by Delta consumptive use, or by being opposed by tidal flow. The amended wet year D-1485 Rio Vista standards require a year-round, daily flow minimums, calculated using a 30-day running average at Rio Vista to benefit migrating salmon. They are set at 2,500 cfs in January; 3,000 cfs from February 1 to March 15; 5,000 cfs from March 16 to June 30; 3,000 cfs during July; 1,000 cfs in August; and 5,000 cfs from September through December.

The Bay-Delta Plan also sets Rio Vista mean-monthly flow minimums of 3,000 cfs, 4,000 cfs, and 4,500 cfs, for September, October, and November-December, respectively. During these compliance periods, the 7-day running average daily mean cannot be more than 1,000 cfs below the required monthly average.

During compliance periods, when both standards apply, the more stringent of the two is in effect. During 1999, the Rio Vista mean monthly flow fell to its lowest level in October, averaging 6,205 cfs, while the 30-day running mean hit its minimum of 5,641 cfs in November. All Rio Vista flow standards and objectives were met during 1999 (Figure 4-6 and Table 4-7).

Net Delta Outflow Index

Tidal action makes direct measurement Delta outflow impractical. However, since net outflow All NDOI standards and objectives were met during 1999. Monthly average of NDOI was the highest in February with 105,538 cfs, less than half of the average NDOI for February 1998 (244,739 cfs). When compared to 1998, which enjoyed abundant Delta outflows, the monthly averages of NDOI for 1999 were much closer to the standards and objectives of the Bay-Delta Plan and amended D-1485. The lowest monthly average of 1999 occurred in October with 4,318 cfs (Table 4-8 and Figure 4-7).

is one of the primary factors in controlling Delta water quality, the Net Delta Outflow Index was developed as part of the Bay/Delta Accord. NDOI is derived using flows from the Sacramento River, the San Joaquin River at Vernalis, the Yolo Bypass, the Eastside stream system (the Mokelumne, Cosumnes, and Calaveras Rivers), and discharges from the Sacramento Regional Wastewater Treatment Plant. Major Delta exports and an estimated in-Delta water use factor is then deducted from the cumulative inflow total to produce the index. Monthly NDOI flow minimums are included in the Bay-Delta Plan and amended D-1485. When NDOI objectives or standards overlap, the more stringent of the two apply. During January, the minimum monthly flow is set at 6,000 cfs when PMI is greater than 800 taf. The wet-year minimum monthly NDOI objectives for July, August, September, and October are 8,000 cfs, 4,000 cfs, 3,000 cfs, and 4,000 cfs, respectively, and they rise to 4,500 cfs for November and December. During February through June, the Bay-Delta Plan sets a minimum daily NDOI of 7,100 cfs calculated as a 3-day running average. The objective may be also met by a daily average or 14-day running average EC of 2.64 mS/cm at Collinsville for a specified number of days determined by PMI. The amended D-1485 standard sets more stringent monthly NDOIs from January through July. Monthly NDOI minimums during January are 6,600 cfs and rise to 10,000 cfs from February through May and in July. During June, the monthly NDOI standard rises to 14,000 cfs.

Delta Exports

The Sacramento-San Joaquin Delta provides the major source of water for SWP deliveries south of the Delta. Inflow from the Kern River Intertie and storm flows entering the California Aqueduct are also water sources for the SWP, although there were no floodwater flows in 1999.

Banks Pumping Plant has the capacity to export at a rate of 10,670 cfs, although the Aqueduct capacity below Banks Pumping Plant physically limits exports to 10,300 cfs. In addition, a Corps

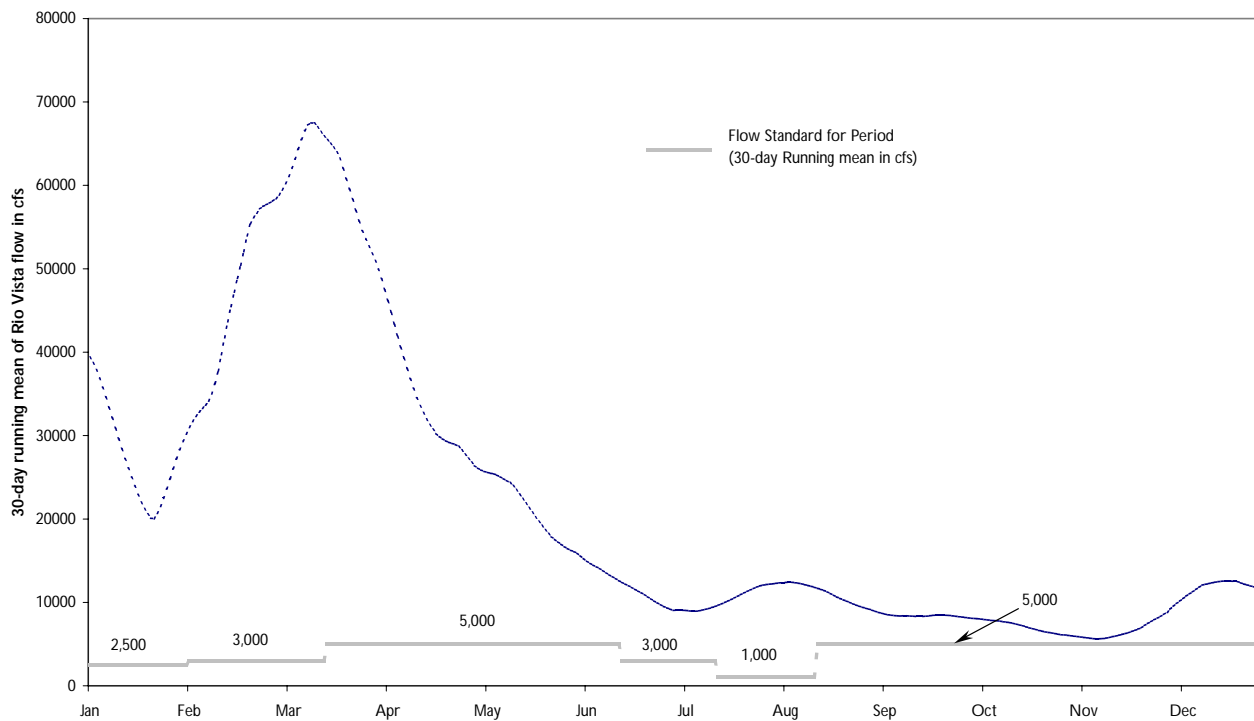


Figure 4-6. Sacramento River Wet-Year Flow Minimums at Rio Vista, 1999

Table 4-2. Sacramento River Wet-Year Standards and Objectives at Rio Vista, 1999 (cfs)

Period	D-1485 Standards	Bay-Delta Plan Objectives	Period Values	
	Minimum daily 30-day running mean in period	Minimum mean monthly ^a	Lowest daily 30-day running mean in period	Mean monthly flow
Jan	2,500	—	20,056	—
Feb 1 - Mar 15	3,000	—	30,991	—
Mar 16 - Jun 30	5,000	—	9,368	—
Jul	3,000	—	8,942	—
Aug	1,000	—	9,321	—
Sep	5,000	3,000	8,240	8,240
Oct	5,000	4,000		6,205
Nov	5,000	4,500		8,092
Dec	5,000	4,500		11,782

^a7-day mean not less than 1,000 cfs below monthly mean.

Note: During compliance periods when both standards or objectives apply, the more stringent of the two is in effect.

permit (Public Notice 5820A) limits the diversion rate at Clifton Court Forebay to 6,680 cfs except from December 15 to March 15. During this time, exports may increase by one-third of the San Joaquin River flow when its flow

exceeds 1,000 cfs. The 1999 San Joaquin River flow at Vernalis was in excess of 1,000 cfs all year, allowing corresponding increases in the export rate. Export pumping rates are increased on weekends to take advantage of less expen-

sive off-peak electrical energy. This produces sharp peaks in the export rate at about 7-day intervals (Figure 4-8).

Banks Pumping Plant is supplied by Clifton Court Forebay, which provides storage for off-peak pumping and acts to buffer the effect of pumping on water levels in nearby Delta channels. Water enters Clifton Court Forebay and then flows to the pumps through the fish salvage screens of the Skinner Fish Facility at the entrance of the intake channel to the SWP export

pumps. (The Skinner Fish Facility intercepts fish that would otherwise make their way to the export pumps.)

In 1999, the SWP diverted 2.71 maf at Banks Pumping Plant, about 160 percent of 1998 exports (1.69 maf), and 66 percent of all SWP deliveries, both SWP contractual and non-contractual amounts (4.01 maf). Under the 1986 COA, SWP may export water for CVP later

Table 4-3. Bay-Delta Plan and Amended D-1485 NDOI Flow Objectives, 1999 (cfs)

Objectives and Flows	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<i>NDOI - Bay-Delta</i>												
MM>	6,000 ^a						8,000	4,000	3,000	4,000	4,000	4,500
Min. daily 3-dm		7,100	7,100	7,100								
Min. daily 14-dm					4,000 ^b	4,000						
<i>NDOI - D-1485</i>												
MM>	6,600	10,000	10,000	10,000	10,000	14,000	10,000					
PM>				Apr 1-14 6,700	May 6-31 14,000							
<i>Actual Flows</i>												
MM	36,376	105,538	73,792	34,995	22,937	14,072	10,817	6,142	4,522	4,318	6,506	10,810
PM				Apr 1-14 33,549	May 6-31 21,621							
Min 3-dm or 14-dm		38,966	41,171	30,061	18,479	10,985						

^aPMI >800 taf, January objective rises to 6,000 cfs

^bMay 1, 1999 estimate of Sacramento River Index was less than 8.1 maf for which the Bay-Delta Plan allows NDOI minimums for May and June to be reduced to 4,000 cfs.

Note: During months with both Bay-Delta Plan objectives and amended D-1485 standards, the most stringent of the two applies. Shaded areas = objective; MM = mean month; 3-dm = 3-day mean; 14-dm = 14-day mean; PM = period mean

in the year to make up for exports not taken at its Tracy Pumping Plant under D-1485 fisheries limitations. WR 95-06 allowed the SWP and CVP to use either project's pumping plants for exports to make up for export losses incurred for the protection of fisheries. These export exchanges may not jeopardize either project's deliveries and requires permission from the CALFED Operations Group. During 1999, Banks Pumping Plant pumped 60,283 af of water for CVP (Table 4-9).

Winter-run Chinook Salmon Export

Restrictions. The long-term Winter-run Chinook Salmon Biological Opinion, amended in March 1995, set limits on Delta exports, based on the combined loss of winter-run sized salmon smolt at the State and federal Delta export facilities, known as the *take level*. This Opinion's incidental take statement invoked a yellow-light warning condition when combined loss (Banks and Tracy) reached 4,548 smolts, equivalent to 1 percent of the 1998 estimated out-migrating juvenile winter-run salmon population. The projects voluntarily adjust export

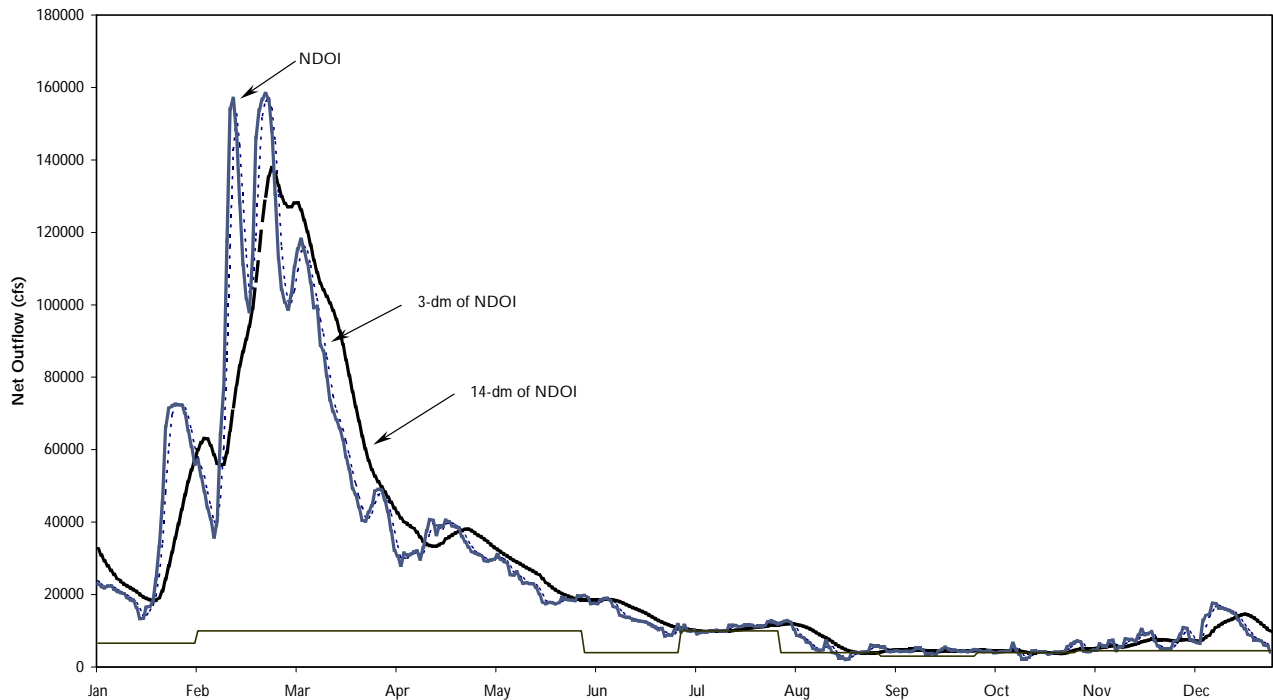


Figure 4-7. Net Delta Outflow Index, 1999

conditions to reduce loss numbers when yellow-light conditions are reached. Loss levels at 2 percent, or 9,095 smolts, trigger a red-light condition that initiates consultation with the Winter-run Chinook Salmon Monitoring Group. These yellow and red-light export restrictions were in effect from October 1998 through May 1999, expanded by empirically determined factors including sampling duration, salvage efficiency, forebay predation, and losses due to handling and hauling.

The combined seasonal, winter-run sized salmon loss for 1999 was 3,715 smolts. Exports were not affected, as the loss did not trigger the yellow-light level of concern (Figure 4-9).

Delta Smelt Export Restrictions. The amended Delta Smelt Biological Opinion established a year-round Delta smelt salvage action level of 400 fish (14-day running mean of daily salvage), known as the *yellow-light level* that triggers informal consultation with the Department, USFWS, DFG, and the Bureau. The combined salvage is the sum of Delta smelt salvaged at CVP Tracy and SWP Banks Pumping Plants

1999, the predominant period of salmon migration. The fish loss or estimated take is a calculated value derived from combined salvage numbers at SWP and CVP fish facilities,

expanded by other factors similar to those used in the winter-run salmon calculation. The red-light level varies with the month of the year and water year type, with below-normal water years generally having a higher red-light level than the level set for above-normal water years. Reaching the red-light level triggers formal consultation with the fisheries agencies to determine whether additional actions are necessary to avoid jeopardizing the species.

Following the spring pulse flow period of 1999, for which the export facilities had been utilizing export and flow targets included in the amended Delta Smelt Biological Opinion, combined exports were increased to 4,000 cfs on May 19. That same day, the yellow-light level of concern was reached and on May 20, the red-light level of 9,769 Delta smelt was surpassed,

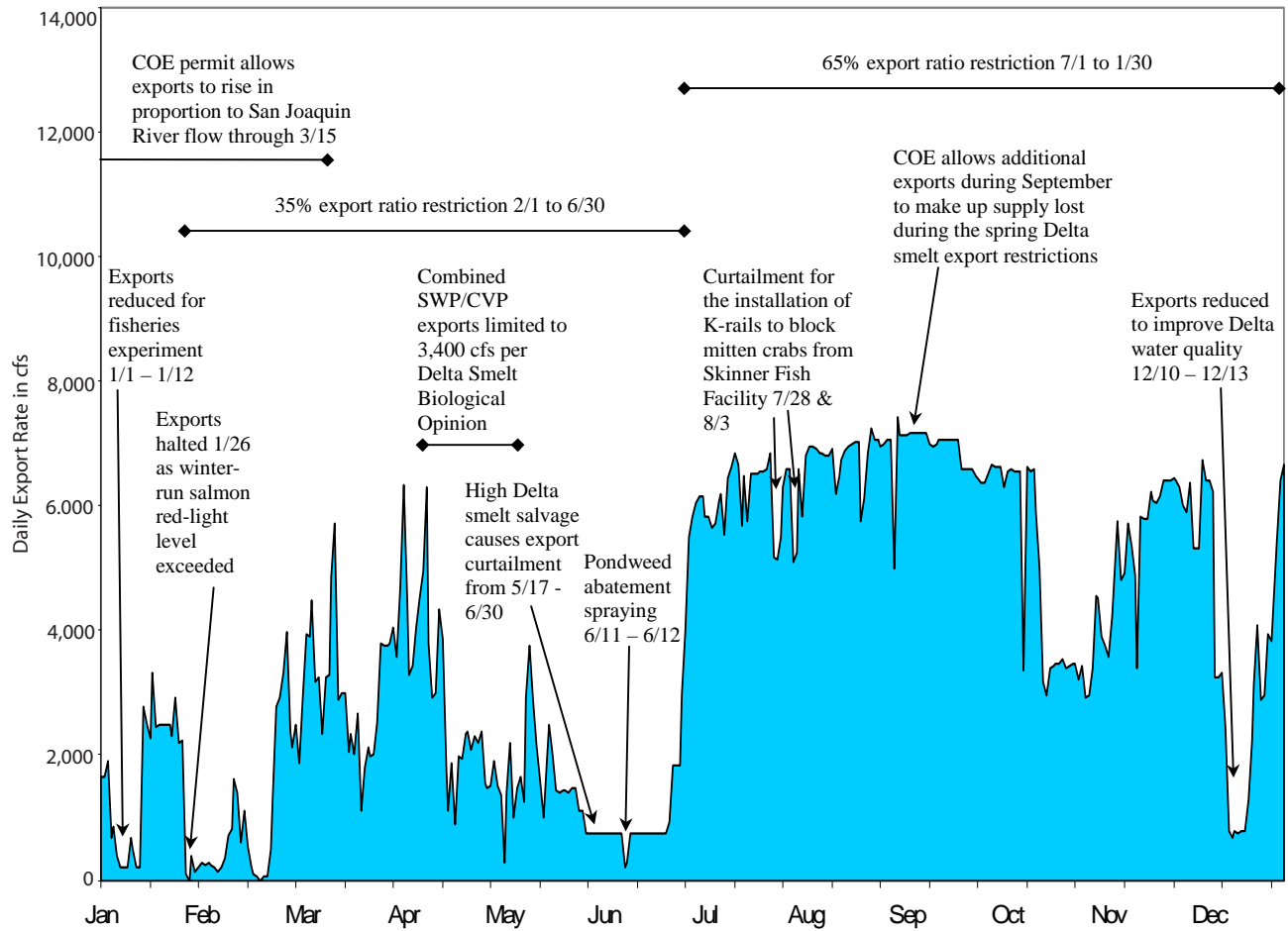


Figure 4-8. SWP Delta exports during 1999

Table 4-4. Delta Exports at Tracy and Banks Pumping Plants during 1999

Month	SWP (cfs)	Banks Export For SWP (af)	Banks Export For CVP (af)	Total Banks Exports (af)	Total Tracy Exports (af)	SWP/CVP Combined Exports (af)
Jan	3,197	196,572	0	196,572	243,014	439,586
Feb	131	7,285	0	7,285	164,144	171,429
Mar	233	14,309	0	14,309	126,792	141,101
Apr	31	1,871	0	1,871	86,007	87,878
May	726	43,225	0	43,225	142,654	185,879
Jun	1,970	128,947	0	128,947	170,308	299,255
Jul	3,471	213,401	0	213,401	249,614	463,015
Aug	4,296	264,172	0	264,172	268,748	532,920
Sep	4,474	266,203	0	266,203	259,261	525,464
Oct	4,787	280,894	0	294,812	255,695	550,507
Nov	2,176	129,489	0	129,489	127,028	256,517
Dec	2,082	113,836	14,190	128,026	2,052	130,078
Total	-----	1,660,204	14,190	1,688,312	2,095,317	3,783,629

triggering formal consultation with USFWS. As a result, combined exports were reduced to 3,500 cfs on May 21. The CALFED Operations Group met on May 25 and the Department and the Bureau agreed to further reduce combined

exports to 3,500 cfs through the end of May due to the continued high salvage of Delta smelt. Despite the export reductions, total monthly salvage of Delta smelt reached 58,943 by the end of

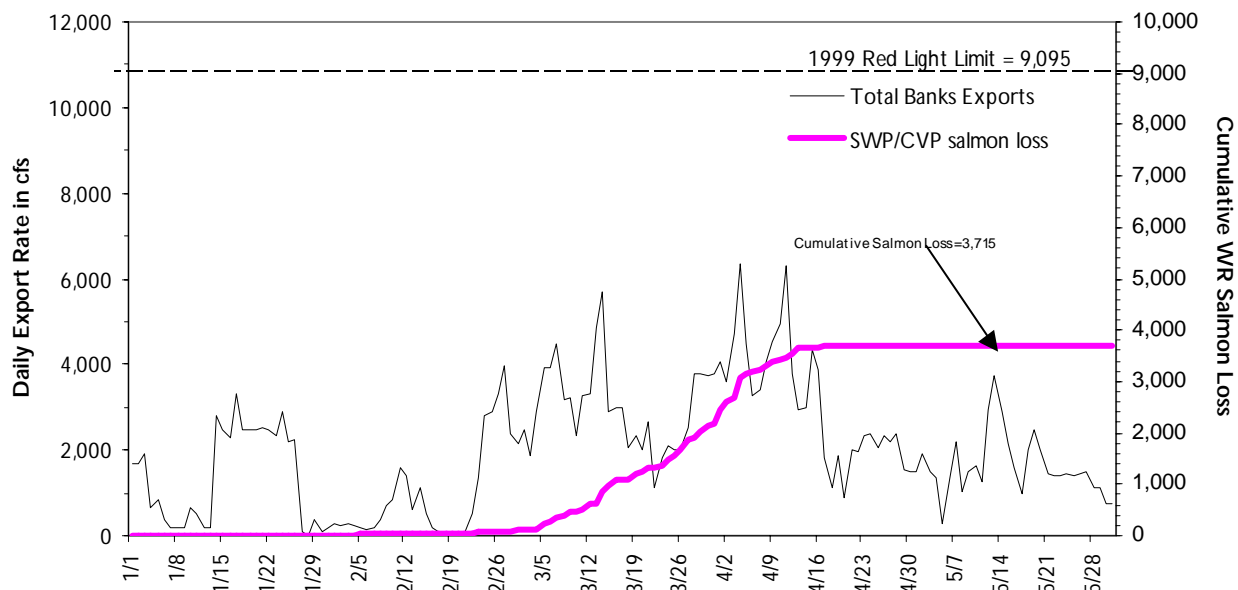


Figure 4-9. SWP/CVP cumulative winter-run salmon loss estimate and Banks total export, January 1, 1999, to May 31, 1999

May, exceeding the red-light level by more than 6-fold.

During June, the combined salvage remained high at the SWP and CVP facilities, exceeding the June red-light level (10,709) on June 6. By June 18, Delta smelt salvage had declined allowing an increase in combined exports beginning on June 20 and doubling by June 30 to about 7,500 cfs. Salvage numbers increased with the stepped-up export rate. More than 22,500 Delta smelt were salvaged on June 29 and 30. Combined salvage for June exceeded the red-light level 7-fold with a total of 73,368 Delta smelt. Salvage declined after July 3 and by mid-month, the combined salvage had fallen below the yellow-light level of concern (Figure 4-10).

Sacramento Splittail Listing

USFWS listed the Sacramento splittail as threatened under FESA on February 8, 1999. The listing, which became effective on March 10, had been under consideration since 1994. During 1999, the Department and the Bureau met with USFWS in an effort to establish an incidental take statement for the operation of the SWP and CVP. Though no formal take limits for splittail were in place, the fish salvage facilities of the SWP and CVP kept an accurate count of the combined splittail salvage during 1999, which is illustrated in Figure 4-11.

Impact of Chinese Mitten Crabs

During the summer of 1999, the Department and the Bureau installed devices to deter Chinese mitten crabs from interfering with pumping and fish salvage operations at the south Delta export facilities of the SWP and CVP. The CVP installed a specially designed screen at the federal fish facility, while the SWP installed an underwater barrier resembling a highway divider near the Skinner Fish Facility. This underwater barrier, installed at an angle to water flow, is designed to guide the crabs crawling along the bottom into collection traps.

These preventative measures were undertaken as a result of the deluge of mitten crabs that arrived at the State and federal fish facilities and hindered salvage operations in the fall of 1998. Far fewer mitten crabs arrived in the fall of 1999. In fact, during October 1999, Skinner Fish Facility collected about 30,000 mitten crabs, compared to October of the previous year when 10,000 crabs were collected each day. Mitten crabs did not create a significant problem for SWP south Delta pumping or fish salvage operations during 1999.

Bay-Delta Plan Export Restrictions. The 1995 Bay-Delta Plan contains a year-round export objective that restricts exports by setting them in proportion to Delta inflow. This percent inflow diverted objective varies by month and is conditioned by PMI. The 1999 combined SWP/CVP export objective was set at 35 percent of Delta inflow from February through June and 65 percent during January and the remainder of the year.

The actual export amount is calculated using the combined inflow rate for Clifton Court Forebay (excluding Byron-Bethany Irrigation District diversions from Clifton Court Forebay) added to the exports from Tracy Pumping Plant. The percent inflow diverted is then determined by dividing this sum by the total inflow into the Delta. The percent inflow diverted objective is calculated using a 3-day running average of exports and a 14-day running average of Delta inflow. This changes during periods when CVP or SWP exports are dependent upon storage withdrawals from upstream reservoirs, in which case both export rate and the Delta inflow are calculated as 3-day running averages.

During January 1999, the percent inflow diverted average was only 14 percent even though as much as 65 percent is allowed for the month. This was due in part to a Delta fisheries test that limited combined exports to below 2,000 cfs from December 29, 1998, to January 12, 1999. In addition, exports at Banks were halted

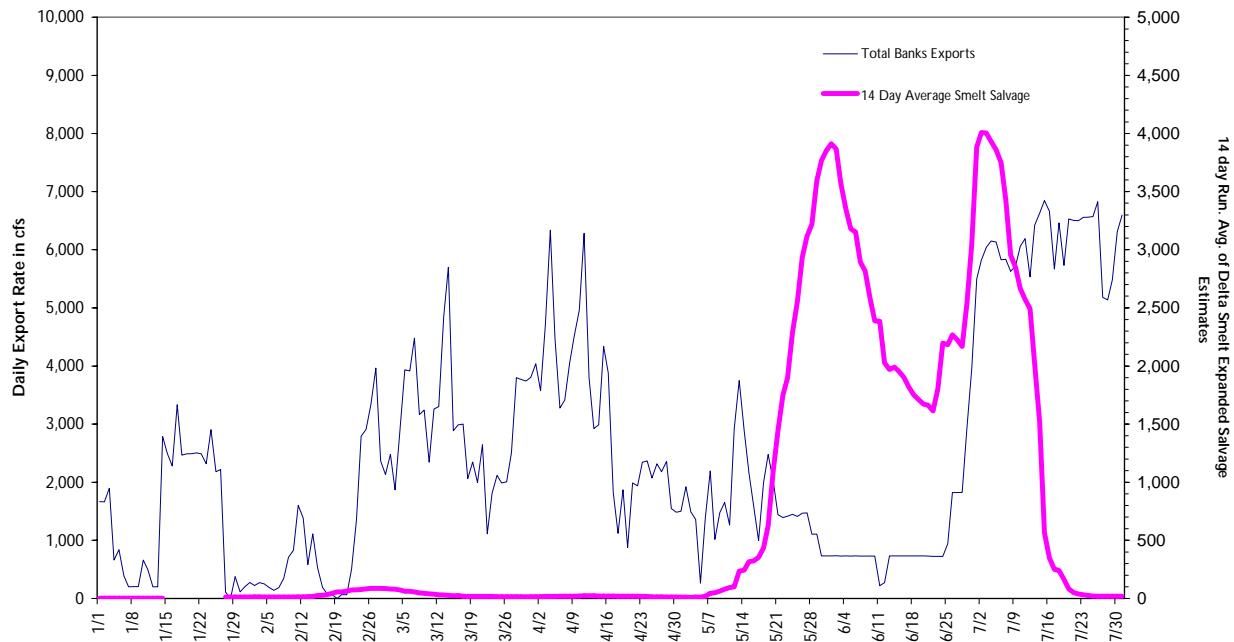


Figure 4-10. Expanded Delta smelt salvage estimates and Banks export pumping, January to July, 1999



The Sacramento-San Joaquin Delta includes 57 islands, more than 1,000 miles of levees, and hundreds of thousands of acres of marshes, mudflats, and farmland.

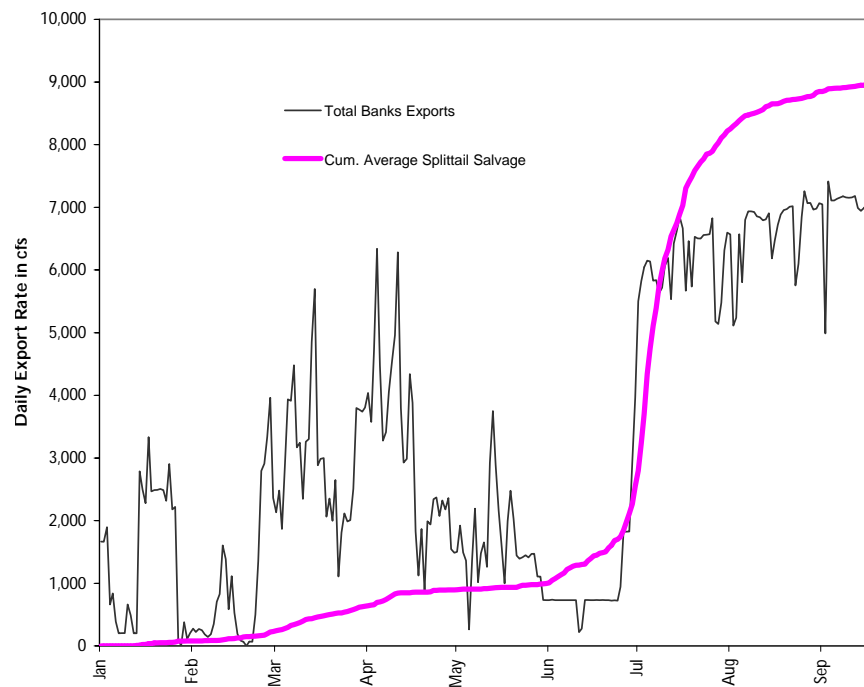


Figure 4-11. Expanded Sacramento splittail salvage estimates and Bank December, 1999

on January 26 as a result of the winter-run salmon red-light level being exceeded.

During the more restrictive February to June period (35 percent objective), the percent of inflow diverted averaged 12 percent. Within this period, Banks and Tracy Pumping Plants experienced export curtailments in May and June due to high Delta smelt salvage. This curtailment delayed the filling of San Luis Reservoir, subsequently resulting in a loss of about 150 taf of Article 21 water for SWP contractors.

The Bay-Delta Plan also contains an export limitation applied during the spring pulse flow period on the San Joaquin River, limiting combined exports from April 15 through May 15 to 1,500 cfs, or 100 percent of the 3-day average of the San Joaquin River flow at Vernalis, whichever is greater. The San Joaquin River Agreement was completed in April 1998 and includes VAMP. VAMP contains alternate flow and export targets to be used in lieu of the Bay-Delta Plan criteria for the protection of San Joaquin River salmon.

The operators of the SWP and CVP had planned to use the export levels outlined in VAMP for the spring pulse flow season. However, on April 16, 1999, a federal judge issued a restraining order preventing the implementation of any in-Delta AFRP measures unless water was provided to ensure there would be no impact to CVP water users this year or 2000. Since VAMP is an AFRP action outlined in CVPIA, the 1995 Delta Smelt Biological Opinion became the governing criteria for the spring pulse flow period. This resulted in a combined export pumping target approximately 3,500 cfs less than the San Joaquin River flow at Vernalis. Actual combined exports averaged 3,263 cfs during the April 17 to May 17 pulse flow period and about 9 percent of Delta inflow.

On May 13, 1999, the Department and the Bureau began operating the SWP and CVP to achieve the export rates of VAMP and the associated ramping period. This resulted in a reduction of exports to about 3,000 cfs combined. On May 18, following the spring pulse flow period, the SWP and CVP increased combined exports to 4,000 cfs. By May 20, both the yellow-light and the red-light levels of concern were

exceeded for Delta smelt at the State and federal facilities. As a result, combined exports were restricted to 3,500 cfs for the balance of May. Exports at Banks were also reduced in June due to high smelt salvage.

On June 11 and 12, exports at Banks were curtailed following the lowering of the storage elevation at Clifton Court Forebay for pondweed abatement.

From July through December, the Bay-Delta Plan allows combined exports to increase to 65 percent of Delta inflow and export averaged 50 percent of Delta inflow during this 6-month period. Exports at Banks Pumping Plant were reduced during late July and early August to accommodate the installation of K-rails in the channel between Clifton Court Forebay and Banks Pumping Plant. The K-rails were installed in an effort to block mitten crabs from entering the pumps and the fish salvage facility.

In August and September 1999, the Corps approved increased inflow into Clifton Court Forebay above the nominal rate of 6,680 cfs. This increase was allowed with the intention of making up some of the approximately 324 taf of exports lost in curtailments to protect Delta smelt from mid-April to early July.

The SWP and CVP reduced exports on December 10, 1999, to a combined 4,100 cfs and again on December 14 to 1,600 cfs in an effort to improve Delta water quality. Combined exports remained low through December 20, when exports were gradually ramped up through the end of December.

All Bay-Delta Plan, amended D-1485, ESA-related, and VAMP export criteria were met during 1999 (Tables 4-8 and 4-10, and Figure 4-12).

Real-time Monitoring Program

The 1994 Principles of Agreement endorsed the use of real-time fisheries monitoring to enhance operational flexibility through the adjustment of

export limits while insuring biological protection consistent with the federal and State ESA. The 1999 Real-time Monitoring Program provided water project operators with field information and monitoring data within 36 hours, timely enough to protect targeted fish species from entrainment at the Delta export facilities while providing for water supply reliability. The 1999 Real-time Monitoring Program began on April 1 and ended July 5, 1999. Real-time monitoring efforts during spring and early summer of 1999 sampled 14 Delta sites 5 days per week. The CALFED Operations Group evaluated the field results to determine if there were any need for operational change. Monitoring efforts spe-

cifically targeted winter-run salmon, Delta smelt, and Sacramento splittail.

North Bay Operations

Deliveries to the North Bay Aqueduct constituted about 1 percent of total SWP deliveries during 1999 (40,057 af).

The North Bay Aqueduct system begins in the north Delta at the Barker Slough facilities near Rio Vista. Sacramento River and local watershed water passes through Cache, Lindsey, and Barker Sloughs to reach the Barker Slough

Table 4-5. Bay-Delta Plan Export Limits Based on Percentage of Delta Inflow Diverted, 1999

Month	Maximum % Inflow allowed as combined export	Mean % inflow diverted	
		3-day running mean ^a	14-day running mean ^a
Jan	65	13.0	14.4
Feb		5.8	6.0
Mar		9.3	7.8
Apr ^b	35	12.0	11.2
May ^b		11.5	10.5
Jun		18.9	18.4
Jul		40.4	42.5
Aug		52.1	49.0
Sep	65	60.1	59.1
Oct		59.6	57.1
Nov		56.4	59.0
Dec		33.6	33.7

^aPercent of Delta inflow diverted is calculated using the export rate as a 3-day running means and the Delta inflow as a 14-day running mean, except when the SWP or CVP are making storage withdrawals for export. In this case, both the export rate and Delta inflow are 3-day running means.

^bThe Bay-Delta Plan limits combined April 15-May 15 export rate to 1,500 cfs or 100% of San Joaquin River Flow at Vernalis, whichever is greater (see Table 4-6).

Note: Combined export is defined as Clifton Court Forebay inflow (minus BBID diversions from Clifton Court) plus Tracy Pumping Plant exports.

Pumping Plant. From the Barker Slough Pumping Plant, water is conveyed by pipeline for 24 miles northwest to the Cordelia Pumping Plant. Deliveries are made to Solano County water users via turnouts along the pipeline and to Napa County users from the Cordelia Pumping Plant. NBA extends approximately 6 miles beyond the Cordelia Pumping Plant to the Napa

Terminal Tank. The Aqueduct will ultimately supply 25 taf annually to Napa County and 42 taf to Solano County. In 1999, NBA conveyed 40,057 af of Table A supply. No non-SWP deliveries were made from the NBA in 1999, but 753 af of water under Article 21 was delivered to Napa. Table A deliveries to Solano County made up 87 percent of the total NBA deliveries

(34,753 af) and Napa received 4,550 af, about 11 percent.

Barker Slough Pumping Plant has a maximum pumping capacity of 160 cfs and is screened to exclude juvenile salmon from entrainment; however, the screens are not able to exclude the smaller Delta smelt. The amended Delta Smelt Biological Opinion requires a reduction of diversions from Barker Slough to a 5-day running average of 65 cfs when monitoring efforts at three sites upstream of the plant detect Delta smelt under 20 millimeters. The catch at three stations in Barker Slough is calculated into a

weighted average, with the weight of each station dependent upon the proximity to the Barker Slough pump intake. The opinion also set an estimated numerical loss limit at the pumping plant during Delta smelt spawning season.

From February 16 to July 16, 1999, the Delta smelt catch at the three Barker Slough stations did not rise to the level described in the amended Delta Smelt Biological Opinion to establish Delta smelt presence; consequently, no export reductions were required during 1999.

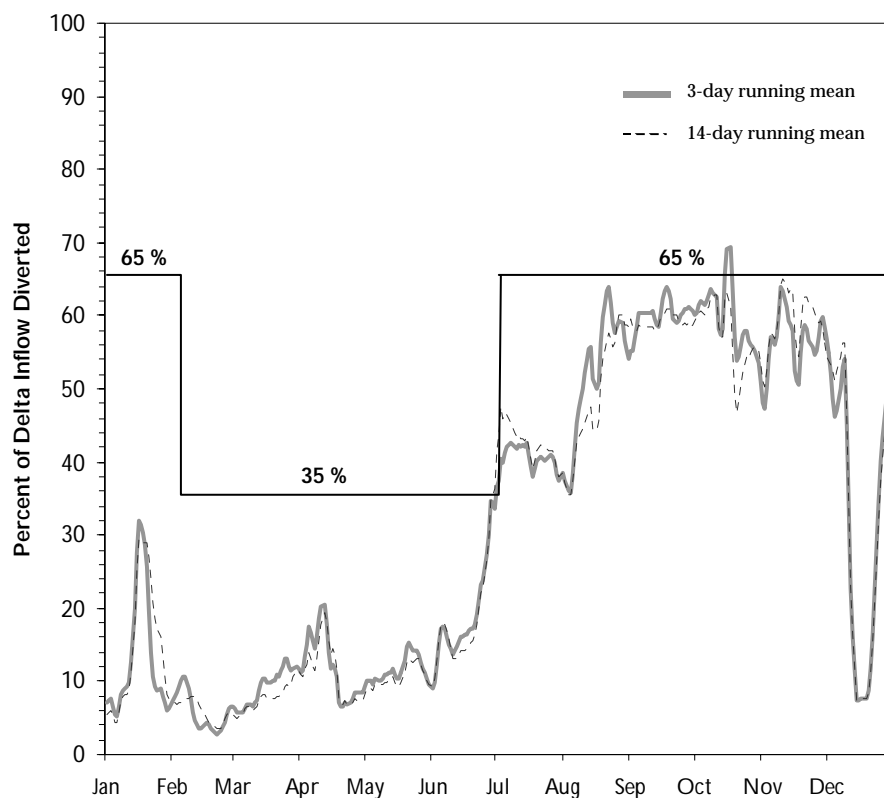


Figure 4-12. Combined Delta exports as percent inflow diverted and Bay-Delta Plan objectives, 1999

Delta Water Management

South Delta Improvements Program

During the latter half of the 1990s, the Department sought to step-up the construction of south Delta facilities to improve Delta water conditions. This was accomplished through the

Interim South Delta Program. In 1999, the CALFED Bay-Delta Program decided to include south Delta facilities as a key component of the CALFED decision-making process. ISDP was subsequently renamed the South Delta Improvements Program and its purpose was revised to focus on the following:

- improve the reliability of existing SWP facilities;
- ensure that water of adequate quantity and quality is available for diversion to the South Delta Water Agency service area for beneficial use; and
- reduce the effects of SWP exports on both aquatic resources and direct losses of fish in the south Delta.

Seasonal Barriers. The seasonal barriers are constructed under the program's South Delta Temporary Barriers Project and are designed to improve local water levels and circulation patterns, protect fishery resources, and improve

water quality. They have been placed across Middle River, Old River at Tracy, Grant Line Canal, and Old River at Head (Figure 4-13). In 1996, the Corps extended the testing program for the temporary barriers another 5 years to include an evaluation of means to improve Chinook salmon survival during spring and fall migrations.

The Old River at Head barrier, a temporary barrier installed in the spring, prevents salmon from straying from their migration route into interior Delta sloughs and channels. During the

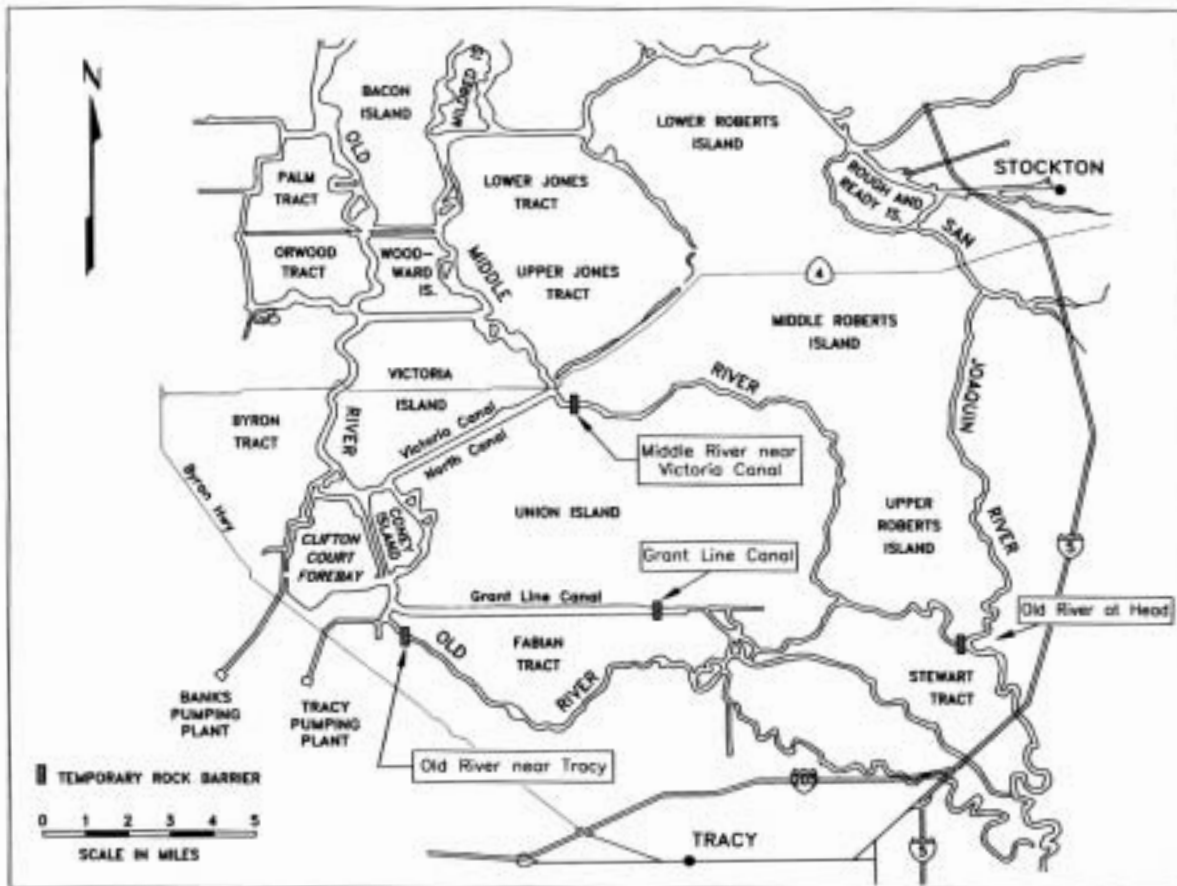


Figure 4-13. South Delta barriers

fall, the Department installs a similar, temporary rock barrier at the same location at DFG's request. The fall barrier helps the salmon migrating upstream remain in their San Joaquin

River migration path by minimizing straying into inner south Delta channels. The Old River at Head fall barrier also improves flows in the San Joaquin River, which helps to alleviate low

dissolved oxygen conditions in the Stockton Deep Water Ship Channel.

The Department is obligated under the San Joaquin River Agreement, which facilitates the implementation of VAMP, to install and operate the Old River at Head fish barrier in a manner that will protect San Joaquin River Chinook salmon smolts, in conjunction with the flows provided during the pulse flow period. The Old River at Head barrier was not installed at all in 1999. During the spring, the barrier was not installed due to high San Joaquin River flows. The fall installation was cancelled at the request of DFG on the basis of the short operational time frame and the associated high installation and removal costs.

The Middle River barrier is a temporary rock barrier installed near Victoria Canal, located about one-half mile south of the confluence of Middle River and Trapper Slough. This tidally controlled barrier improves water circulation and water levels during the agricultural irrigation season. In 1999, the Middle River barrier was installed on May 18 and removal was completed on October 2.

The Old River barrier at Tracy has been installed annually in spring since 1991. The barrier is

installed east of the Delta-Mendota Canal intake at Tracy Pumping Plant. The Old River barrier at Tracy provides similar benefits to those of the Middle River barrier. The Old River at Tracy barrier was installed on May 28 and its removal completed on October 8, 1999.

The Department began installing the Grant Line Canal barrier east of Tracy Boulevard Bridge in 1996. The Grant Line barrier is the last barrier proposed for testing under SDTBP. It is designed to enhance water levels, quality and circulation, and improve agricultural operations. The Grant Line Canal barrier was installed on June 3; however, the barrier's flap gates were tied open due to high Delta smelt salvage, as mandated by the amended Delta smelt biological opinion. A miscommunication within the Department resulted in the flap gates on the Grant Line Canal barrier being closed on June 23 and the barrier placed into operation erroneously until July 12, 1999. The Department notified USFWS of the error on July 30 and subsequently implemented new procedures and checks to prevent this mistake from occurring in the future. Removal of the Grant Line Canal barrier began September 23 and was completed October 5, 1999 (Table 4-11).

Table 4-6. Dates of Installation and Removal of Temporary South Delta Barriers,^a 1999

Barriers	Installation Dates - Completed	Removal Dates - Completed
Middle River	May 18, 1999	October 2, 1999
Old River near Tracy	May 28, 1999	October 8, 1999
Old River at Head Spring Barrier	Not installed due to high San Joaquin River flows	
Fall Barrier	Not installed upon DFG's request	
Grant Line Canal barrier	June 3, 1999 ^b	October 5, 1999

^aSouth Delta Improvements Program Temporary Barriers Project

^bFlap gates on Grant Line barrier tied open from June 3 to July 27 with the exception of the June 23 to July 12 period in which the Grant Line Canal barrier was erroneously placed in operation.

5. Delta Water Quality Standards

Sacramento-San Joaquin Delta water quality is influenced by the quality and quantity of tributary inflows, regulated discharges, agricultural drainage (including drainage from Delta islands), and seawater intrusion into the Delta's western channels. The SWP and CVP are required, under their SWRCB water right permits, to meet the water quality objectives in the Board's 1995 Bay-Delta Water Quality Control Plan, which was designed to protect the beneficial uses of Delta water. The Principles of Agreement, also referred to as the Bay Delta Accord, was designed to balance proposed SWRCB's water quality standards and ESA operational criteria, with the need to provide water supply reliability.

In 1995, D-1485 and D-1422 permits were amended to conform to Bay-Delta Accord principles and the 1995 Bay-Delta Plan through SWRCB's WR 95-06. In some cases, the Bay-Delta Plan water quality objectives may differ from those in the retained and amended

D-1485 standards. Whenever this occurs, the more stringent of the two applies. On December 29, 1999, the SWRCB's 1995 Bay Delta Plan objectives became standards with the adoption of Decision 1641 and the Final EIR covering the implementation of these standards.

Water quality standards and objectives are categorized by the beneficial uses they are intended to protect under broad categories that include municipal and industrial, agricultural, and fish

and wildlife. The water quality compliance stations, including Suisun Marsh sites, are shown in Figure 5-1. The Department utilizes the following measures to meet Bay-Delta Plan objectives and amended D-1485 water quality and flow standards: (1) releases from upstream reservoirs; (2) operation of the Delta Cross Channel Gates; (3) Delta exports operations; and (4) the construction of temporary rock barriers.

The 1995 Bay-Delta Plan incorporates the D-1422 San Joaquin River salinity standard at Vernalis and a multi-location San Joaquin River dissolved oxygen



A Greek cargo ship steaming up the San Joaquin River on its way to the Port of Stockton. Bradford Island is in the foreground; Sherman Island is in the background.

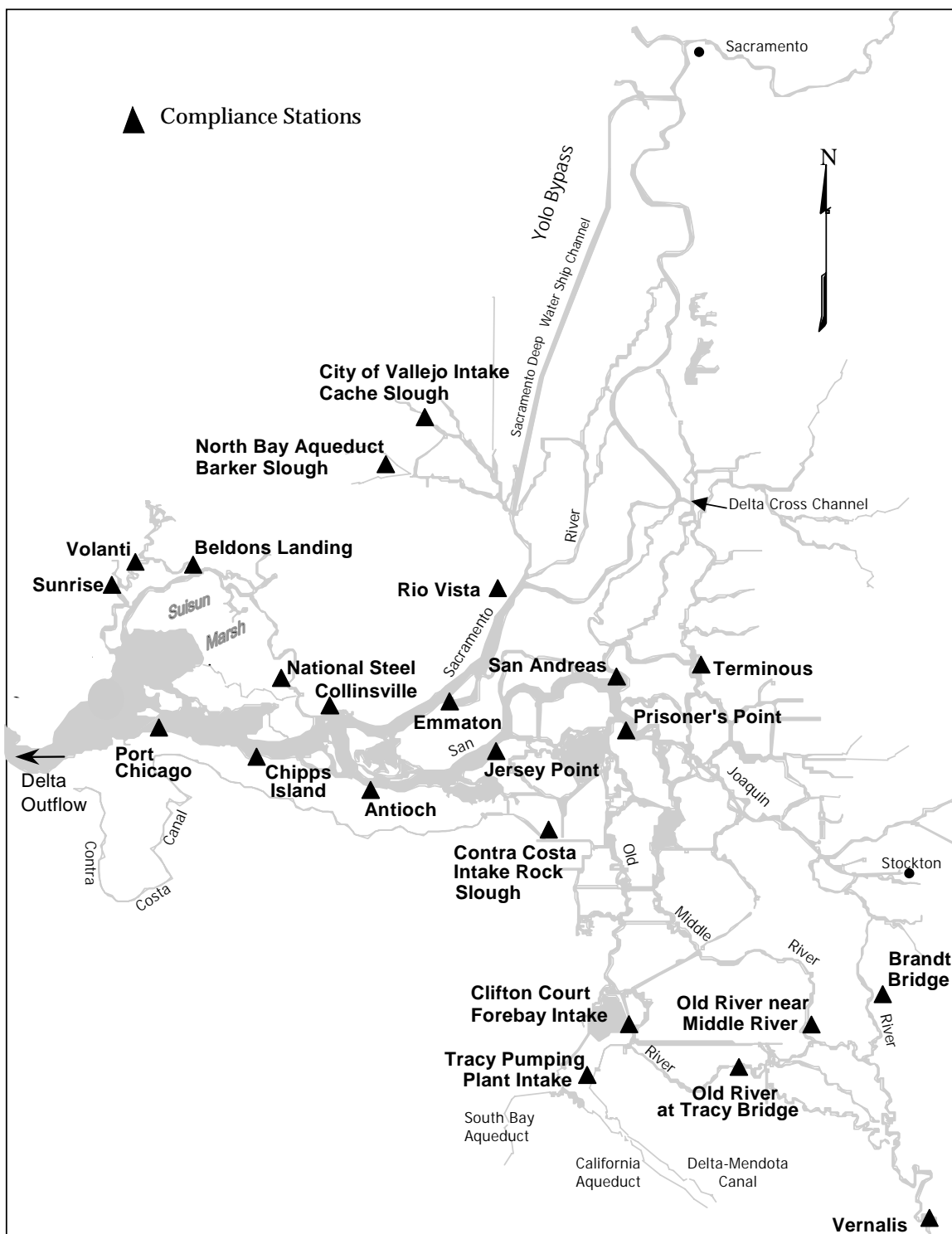


Figure 5-1. The location of the SWRCB 1995 Bay-Delta water quality compliance stations in the Sacramento-San Joaquin Delta (indicated by triangles)

objective. The Plan also introduced a narrative objective for salmon protection and for the protection of brackish tidal marshes of Suisun Bay. Operational objectives and standards are summarized in Table 5-1.

Municipal and Industrial Standards

Municipal and industrial water quality standards based on mean daily chloride values are set at the Delta export locations — Clifton Court Forebay, Tracy Pumping Plant, Contra Costa Canal at Pumping Plant #1, Barker Slough, and Cache Slough. Clifton Court Forebay is at the start of the SWP's California Aqueduct and Tracy Pumping Plant is at the start of CVP's Delta-Mendota Canal. Contra Costa Canal Intake at Rock Slough is at the start of a supply canal that conveys water to eastern Contra Costa County. Cache Slough is an intake for the City of Vallejo. The Cache Slough standard was not in effect in 1999 because water had not been withdrawn from the site in several years. A mean daily chloride standard of not more than 250 mg/L was in effect for the entire 1999 calendar year at all the other export locations and was met at all stations except Contra Costa Pumping Plant #1 (Figure 5-2).

On December 20, 1999, the municipal and industrial chloride standard was exceeded for 1 day at the Contra Costa Pumping Plant #1 on Rock Slough, averaging 258 mg/L. Delta water quality began gradually deteriorating following the closure of the Delta Cross Channel Gates on November 26, 1999. The closure was requested by NMFS and DFG for the protection of spring-run salmon yearlings. The closure occurred during a period of high exports and relatively low Delta inflow, which contributed to a salinity increase in Delta water.

By early December, Delta salinity levels began exceeding the triggering criteria in the Spring-run Salmon Protection Plan for the opening of the Delta Cross Channel Gates. The CALFED Operations Group met on December 8 to discuss the salinity problem and the options suggested

by the Data Assessment Team but failed to make a decision on the positioning of the Delta Cross Channel Gates. The decision was forwarded to the CALFED Water Management Team meeting on December 9 for resolution. The Department and the Bureau announced at the Management Team meeting, an export reduction and increased releases to the Feather River. The Delta Cross Channel Gates remained closed, relying on the export reductions and increased releases to remedy the Delta salinity problem. SWP exports were reduced further on December 13 to 800 cfs.

The Delta Cross Channel Gates were opened for 5 hours on December 14 and opened again on December 15 at 9:00 a.m.; they remained open for the balance of the year. However, the salinity level at the Contra Costa Plant on Rock Slough continued to rise, exceeding the chloride standard and averaging 258 mg/L on December 20. By the end of December 1999, the chloride concentration receded to about 200 mg/L.

The SWRCB's 1995 Bay-Delta Plan contains an additional municipal and industrial standard requiring that chloride not exceed 150 mg/L for a specified number of days accrued in intervals of at least 2 weeks, at the better of the two stations, either the Contra Costa Canal Pumping Plant #1 or the Antioch Water Works Intake. The percentage of days in the calendar year required by the standard is a function of water year type. It varies between 42 and 66 percent of the year, becoming less stringent under drier conditions. The wet year 240-day (66 percent of the year) criterion was met at the Contra Costa Canal Pumping Plant #1 on August 28, 1999, uninterrupted from the start of the year.

Agricultural Standards

D-1485 sets agricultural EC standards to protect Delta agriculture during the irrigation season (from April 1 to August 15). Compliance locations in the western Delta include Emmaton and Jersey Point, with San Andreas Landing and Terminous in the interior Delta. The Bay-Delta Plan set additional year-round compliance

Table 5-1. Bay-Delta Plan and Amended D-1485 Wet Year Water Quality Standards for the Sacramento-San Joaquin Delta during 1999

Compliance Location	Beneficial Use	Standard
Municipal and Industrial		
Contra Costa Canal Intake, Clifton Court Forebay, Tracy Pumping Plant, Contra Costa Canal Intake, Barker Slough Pumping Plant, and Cache Slough Vallejo Intake	md CL <250	All months
Contra Costa Canal Intake or Antioch Water Intake	daily CL <150	240 days in the year
Agriculture		
<i>Western and Interior Delta</i> Emmaton, Jersey Point, Terminous, and San Andreas Landing	14 dm EC <0.45	April 1-August 15
<i>Southern Delta</i> San Joaquin River at Vernalis	30 dm EC <0.7 30 dm EC <1.0	April-August September-March
<i>Export Area</i> Clifton Court Forebay and Tracy Pumping Plant	mm EC <1.0	all months
Fish and Wildlife		
<i>Dissolved Oxygen</i> San Joaquin River between Turner Cut and Stockton	DO >6.0	September-November
<i>San Joaquin River Salinity</i> Jersey Point to Prisoner's Point	14 dm EC <0.44	April-May
<i>Habitat Protection Slightly Starting Condition</i> February starting salinity: - If January 8-River Index >900 TAF, then the daily or 14-day running average EC at Collinsville ≤2.64 mS/cm for at least 1 day between February 1-14. - If January 8-River Index is between 650 TAF and 900 TAF, then the CALFED's Op Group will determine if this requirement must be met. See Table 5-3 for Determination of Compliance of 2.64 mS/cm at Chipps Island or Port Chicago. <i>Suisun Marsh (see Table 5-4)</i>		

Note: DO: dissolved oxygen (mg/L); CL: chlorides (mg/L); EC: electrical conductivity (mS/cm); md: mean daily; 30 dm: 30-day running mean; 14 dm: 14-day running mean; mm: mean monthly; 28 dm: 28-day running mean.

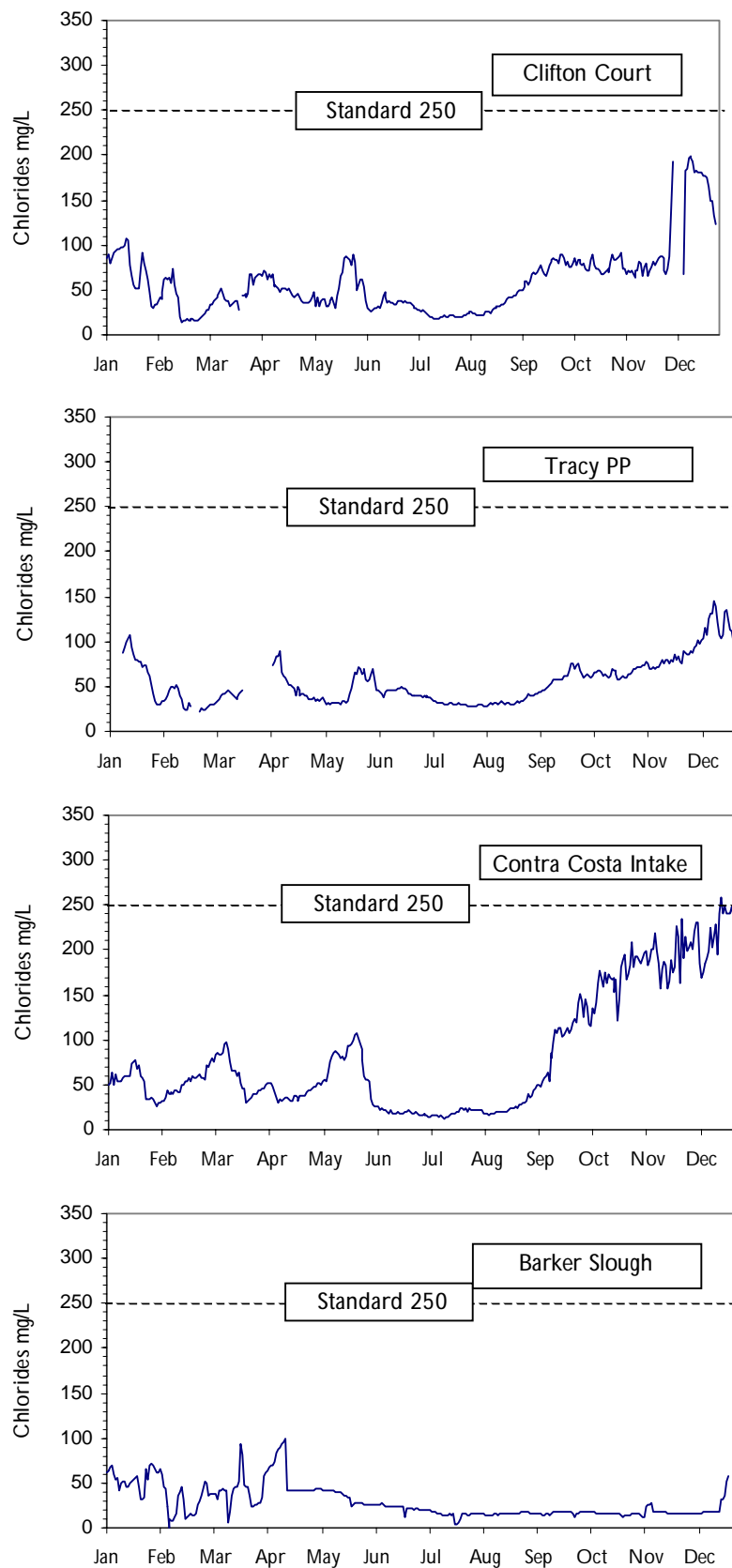


Figure 5-2. Municipal and industrial water quality standards, 1999

locations in the southern Delta at Vernalis and Brandt Bridge, and during September-October near the export areas at Clifton Court Forebay and Tracy Pumping Plant. When hydrologic conditions are drier than average, the standards are relaxed during the latter part of the irrigation season to reflect the water quality that would have occurred in the absence of the SWP and CVP. Under critical-year conditions, relaxation occurs for the entire growing season to reflect salinity intrusions expected with lower basin runoff into the Delta. The wet year agricultural water quality standard is set as a maximum 14-day running average EC of 0.45 mS/cm at Emmaton, Jersey Point, Terminous, and San Andreas Landing. The Vernalis agricultural standard, based on a 30-day running average, is set at 0.70 mS/cm from April through August and rises to 1.0 mS/cm from September through March. The year-round export area standard (maximum monthly average) is also 1.0 mS/cm (Figures 5-3, 5-4, and 5-5).

The responsibility for meeting standards and objectives is generally apportioned under COA to be met by the Department and the Bureau,

with the exception of the south Delta San Joaquin River agricultural objectives at Vernalis and Brandt Bridge. SWRCB allocated the compliance responsibility expressly to the Bureau, as the Department does not regulate any reservoirs upstream of the San Joaquin River. During 1999, the Department met all standards for which it has responsibility under COA and SWRCB. These included the Emmaton, Jersey Point, Terminous, and San Andreas Landing agricultural standards. The Department also has an obligation to maintain water quality for agricultural uses under the 1981 North Delta Water Agency contract, as amended.

Fish and Wildlife Standards

The Bay-Delta Plan and amended D-1485 contain several water quality objectives to protect Delta fish and wildlife. These include a water quality objective for EC on the San Joaquin River measured between Jersey Point and Prisoner's Point and at several locations in the Suisun Marsh. Suisun Marsh standards are



Approximately 520,000 acres of Delta land are devoted to agriculture and produce corn, sugar beets, alfalfa, tomatoes, asparagus, safflower, fruits, and grain crops.

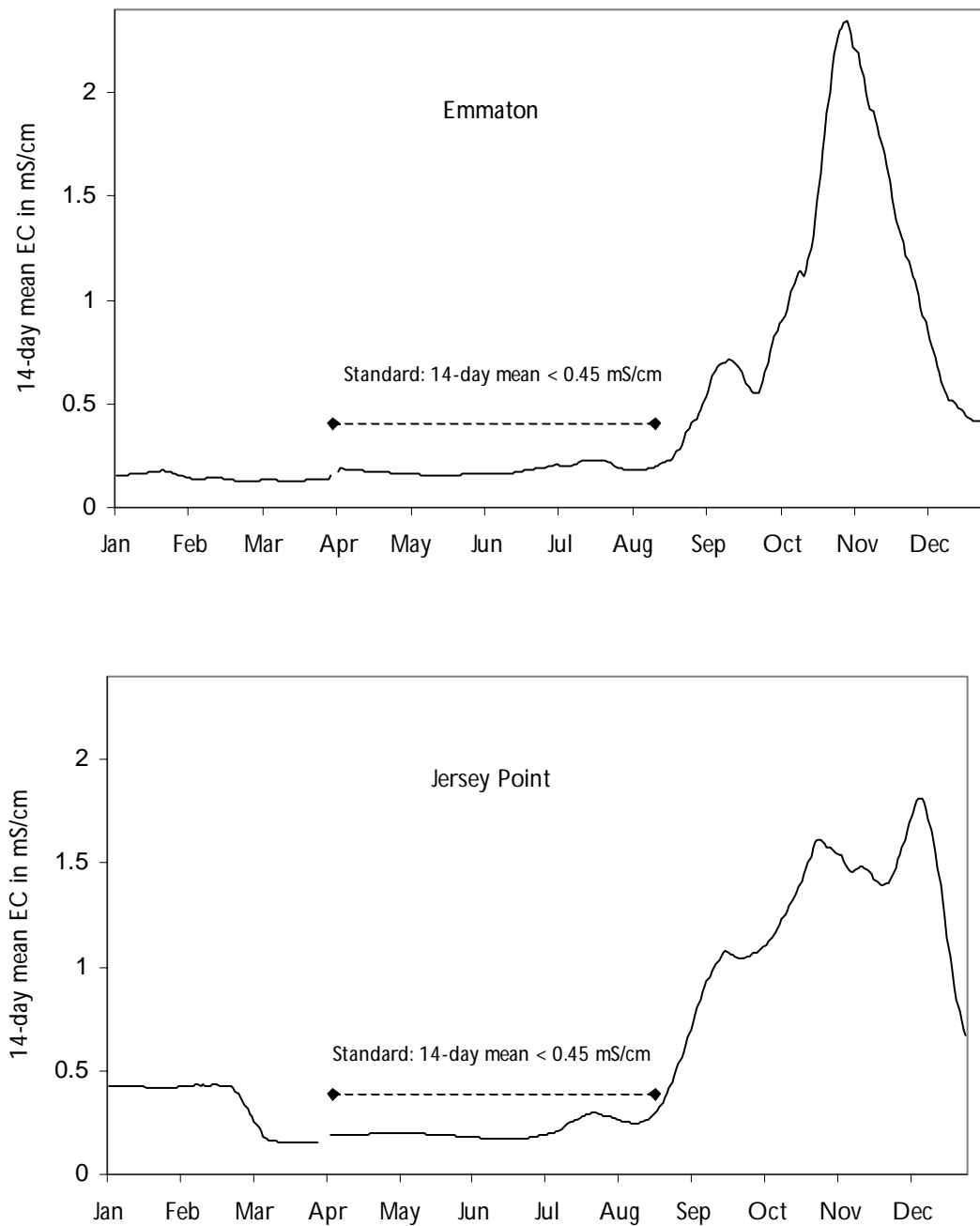


Figure 5-3. Agricultural water quality standards in the western Delta, 1999

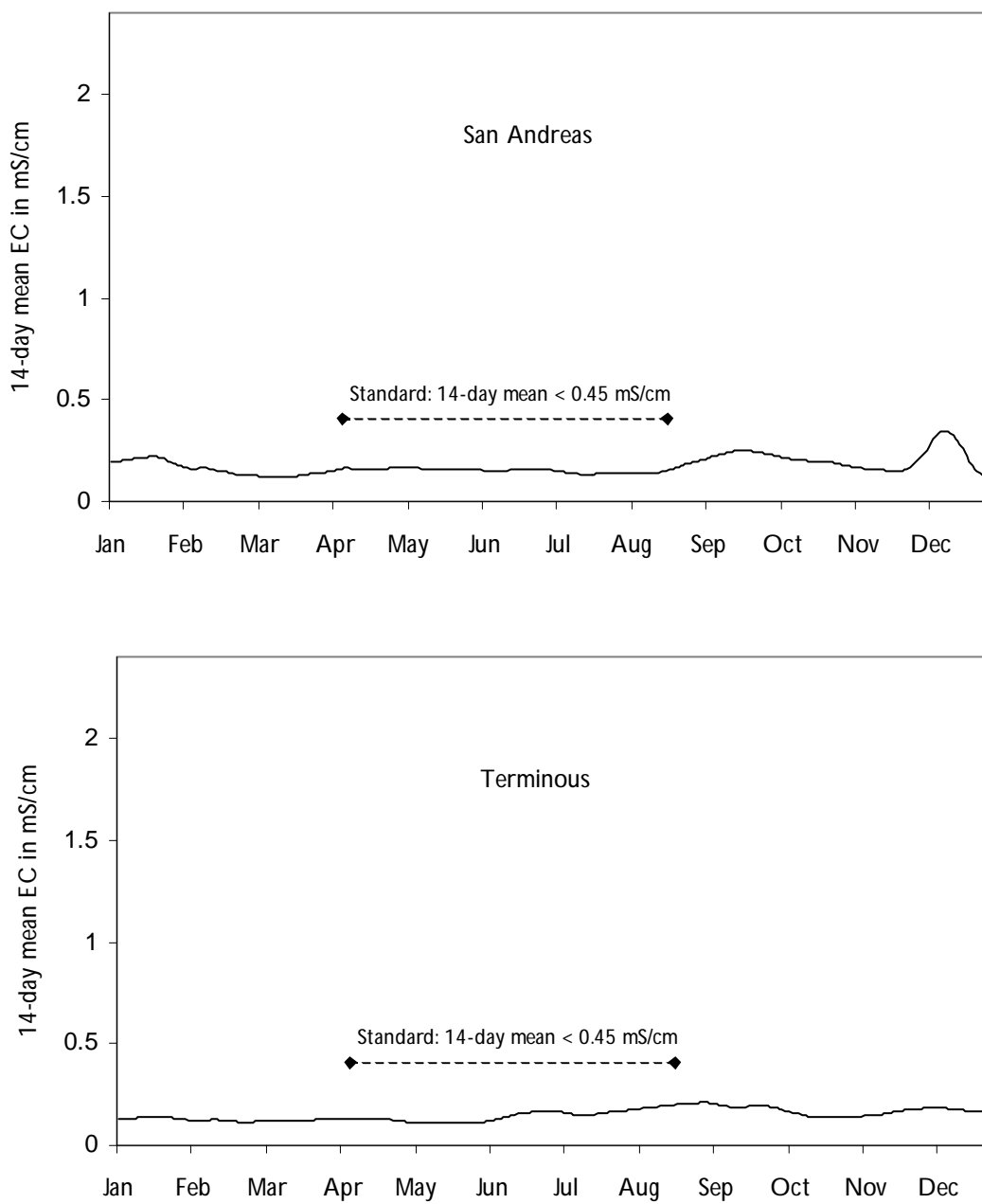
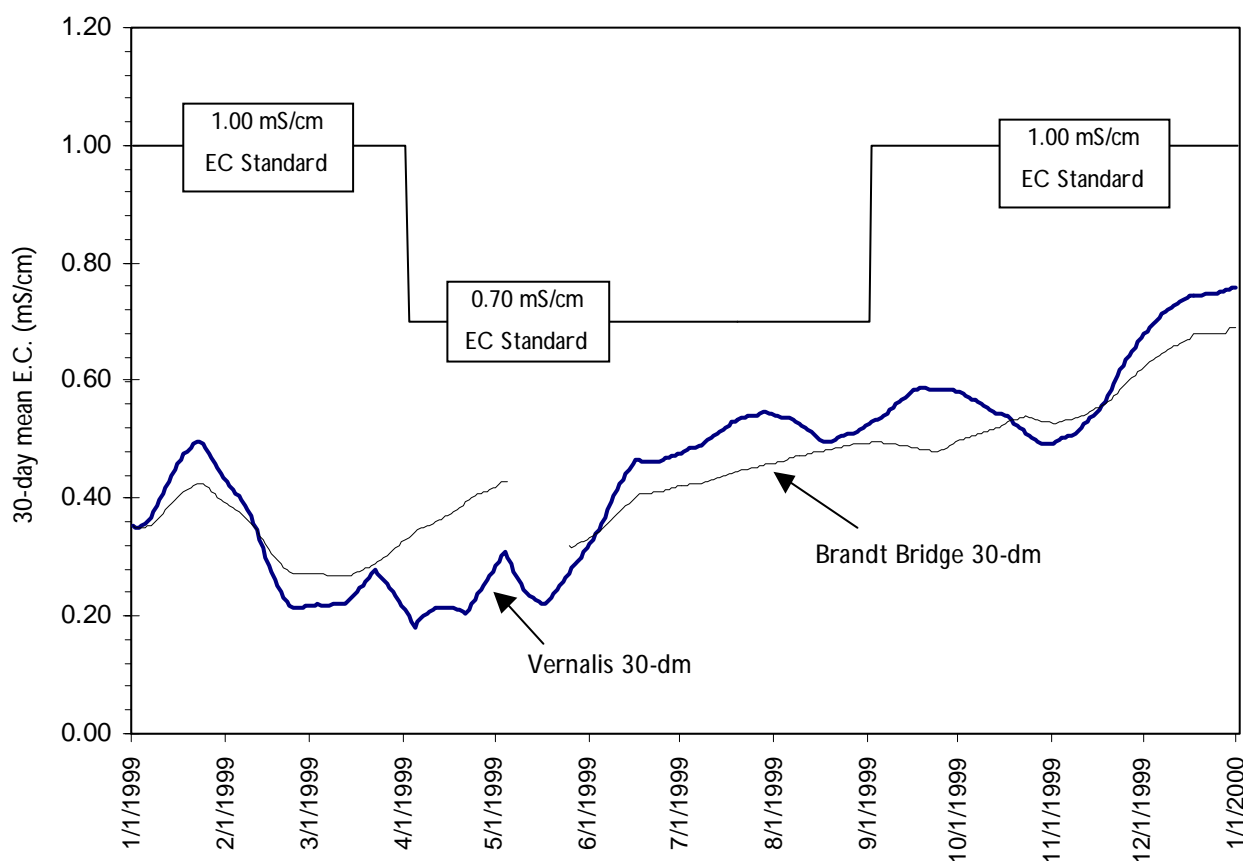


Figure 5-4. Agricultural water quality standards in the interior Delta, 1999



Note: SWRCB assigned responsibility for meeting standards to the Bureau alone.

Figure 5-5. San Joaquin River EC standards, 1999

included below in a more extensive discussion under Suisun Marsh Protection Plan and Preservation Agreement. Other objectives combining both EC and flow were set to protect the estuarine habitat in the Suisun Bay area. A San Joaquin River dissolved oxygen objective was also implemented, having been carried over from D-1422. All of these measures were established in part to encourage spawning and survival of striped bass and to protect migrating salmon.

San Joaquin River Salinity Standard

The Jersey Point and Prisoner's Point objective is set as a maximum 14-day running mean of 0.44 mS/cm during April and May to protect striped bass spawning habitat. Compliance with

the Prisoner's Point EC standard is actually measured at San Andreas Landing, which provides a conservative estimate due to its location west of Prisoner's Point. Jersey Point values averaged 0.19 mS/cm and never exceeded 0.20 mS/cm. EC at San Andreas Landing averaged 0.16 mS/cm for the period and never exceeded 0.17 mS/cm.

Dissolved Oxygen Standard

The Bay-Delta Plan includes a dissolved oxygen standard to protect fall-run salmon migration in the lower San Joaquin River similar to, but more stringent than, the DO standard in D-1422. DO levels are required to be at least 6.0 mg/L during September through November. During late summer and early fall each year, dissolved

oxygen concentrations in the Stockton Ship Channel are closely monitored because they can deteriorate to critically low levels (<5.0 mg/L). DO is measured at 14 sites, at both the water surface and at the channel bottom, between Prisoner's Point and the Stockton Deep Water Channel Turning Basin.

Low oxygen conditions may result from many factors — low stream inflows, intermittent reverse-flow conditions in the San Joaquin River past Stockton, warm water temperatures, reduced tidal mixing, and high biochemical oxygen demand levels as the result of regulated discharges in the Stockton area and recreational activity adjacent to the basin. The Department's Operation Control Office monitors the DO conditions in the Stockton Ship Channel and uses this data as the basis for some operational decisions. The fall installation of the Old River at Head barrier is a commonly used remedy for low DO conditions in the lower San Joaquin River. The barrier increases net flows down the San Joaquin River past Stockton and these increased flows help to improve dissolved oxygen levels, particularly in the eastern channel.

The fall Old River at Head barrier was not installed in 1999 at DFG's request, and the wet water year provided San Joaquin River flows downstream of Vernalis at or in excess of 2,000 cfs throughout the summer and early fall. These relatively high flows were projected to be sufficient to minimize reverse flow conditions past Stockton.

From August through October 1999, average San Joaquin River flows past Stockton ranged from -392 to $+352$ cfs. As a result, river flows into the eastern Stockton Ship Channel were correspondingly low. These low inflows likely contributed to a DO sag (when DO levels are 5.0 mg/L or less) throughout most of the monitoring period. On October 25, 1999, the sag stretched from the eastern end of Rough and Ready Island in the eastern channel to Fourteen Mile Slough in the central channel and extended west to Turner Cut in the central channel. Channel water temperatures were relatively warm in August and early September, reaching as high

as 26° C. The warm water temperatures, coupled with low inflows and high biochemical oxygen demand, likely contributed to this late summer and early fall DO sag in the central and eastern portions of the Stockton Ship Channel. The area in the western ship channel, from Prisoner's Point to Disappointment Slough, typically produces relatively high and stable DO readings throughout the study period and 1999 was not an exception. DO values ranged from 7.7 to 10.0 mg/L during the August 19 to December 7 study period.

In contrast to previous years, DO concentrations did not recover to levels more than 6.0 mg/L in the eastern and central ship channel in November and December, despite increased inflows and cooler water temperatures, which ranged from 10° to 14° C. The slow DO concentration recovery was likely due to channel dredging and the resuspension of sediments, in addition to increased biochemical oxygen demand (Figure 5-6).

Estuarine Habitat Protection Objective (X2)

The Bay-Delta Plan includes an estuarine habitat protection objective that incorporates a modified X2 criteria or geographic isohaline that was first established in the 1994 Delta Smelt Biological Opinion. Delta outflow is used to maintain the position of a 2-ppt isohaline (2 parts per thousand of salt in the water), measured as 2.64 mS/cm on the water's surface at either Chipps Island or Port Chicago from February through June. This required location of the isohaline is associated with fish and biota abundance. The number of days per month when the daily averaged EC maximum (2.64 mS/cm) is in effect at Chipps Island or, under specific conditions, at Port Chicago, are conditioned by PMI and are noted in D-1641's Table 4 (Table 5-2). The Port Chicago standard is usually in effect during months when the Port Chicago 14-day EC average immediately prior to the first day of the month is less than or equal to 2.64 mS/cm. If salinity or flow objectives are met for a greater number of days than the requirement for any

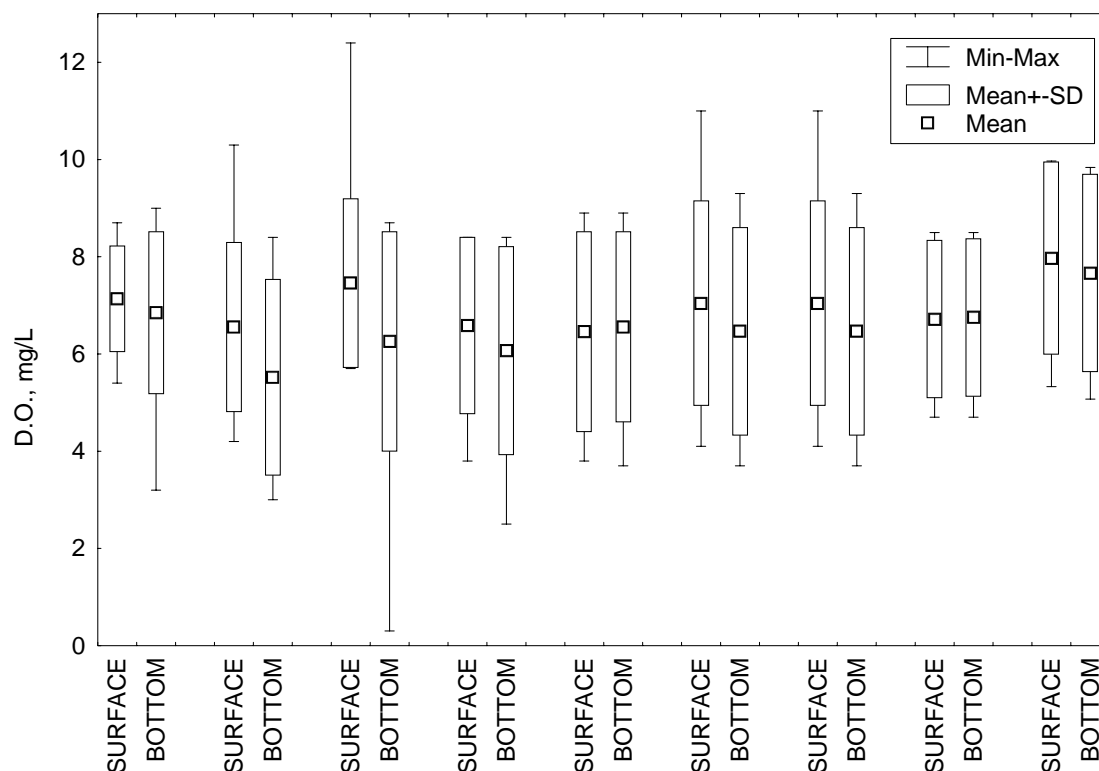


Figure 5-6. Dissolved oxygen concentration in the Stockton Ship Channel, 1999

month, the excess days are applied to meeting the requirements for the following month.

The daily averaged EC objective may be alternately met with a 14-day running average of EC for both locations, or a flow alternative set as a 3-day running average of NDOI for the required number of days. The NDOI objective is set at 11,400 cfs or 29,200 cfs when the X2 is located at Chipps Island or Port Chicago, respectively. During 1999, PMI for February through June was 2.60 maf, 4.59 maf, 3.67 maf, 3.26 maf, and 4.27 maf, respectively. Using Table A, the number of days of compliance maintaining a maximum EC of 2.64 mS/cm at Port Chicago were 23 days for February, and 28 for March, while April and May required 17 and 6 days, respectively. June's X2 requirement at Chipps Island in June was 25 days (Table 5-3).

The X2 Habitat Protection objective was met at Port Chicago during February through May 1999 and was met with the required accumulated number of days of 3-day mean of NDOI

greater than 29,200 cfs. During June, the X2 objective was met using accumulated days of EC below 2.64 mS/cm.

Suisun Marsh Protection Plan and Preservation Agreement

The Suisun Marsh, located in southern Solano County, provides one of the largest estuarine waterfowl habitats in the continental United States and represents more than 10 percent of California's remaining natural wetland habitat. The marsh also provides resting and feeding grounds for thousands of waterfowl migrating on the Pacific Flyway.

Suisun Marsh water quality has been protected since 1971, first through the SWRCB's D-1379 and later in 1978 by D-1485. In 1987, the Department signed the Suisun Marsh Preservation Agreement in conjunction with the Bureau, DFG, and the Suisun Resources Conservation District, which represents private landowners.

Table 5-2. Bay-Delta Standards Table A: Habitat Protection Outflow

Chippis Island						Port Chicago					
PMI (TAF)	Feb	Mar	Apr	May	Jun	PMI (TAF)	Feb	Mar	Apr	May	Jun
500	0	0	0	0	0	0	0	0	0	0	0
750	0	0	0	0	0	250	1	0	0	0	0
1,000	28 ^a	12	2	0	0	500	4	1	0	0	0
1,250	28	31	6	0	0	750	8	2	0	0	0
1,500	28	31	13	0	0	1,000	12	4	0	0	0
1,750	28	31	20	0	0	1,250	15	6	1	0	0
2,000	28	31	25	1	0	1,500	18	9	1	0	0
2,250	28	31	27	3	0	1,750	20	12	2	0	0
2,500	28	31	29	11	1	2,000	21	15	4	0	0
2,750	28	31	29	20	2	2,250	22	17	5	1	0
3,000	28	31	30	27	4	2,500	23	19	8	1	0
3,250	28	31	30	29	8	2,750	24	21	10	2	0
3,500	28	31	30	30	13	3,000	25	23	12	4	0
3,750	28	31	30	31	18	3,250	25	24	14	6	0
4,000	28	31	30	31	23	3,500	25	25	16	9	0
4,250	28	31	30	31	25	3,750	26	26	18	12	0
4,500	28	31	30	31	27	4,000	26	27	20	15	0
4,750	28	31	30	31	28	4,250	26	27	21	18	1
5,000	28	31	30	31	29	4,500	26	28	23	21	2
5,250	28	31	30	31	29	4,750	27	28	24	23	3
5,500	28	31	30	31	30	5,000	27	28	25	25	4
						5,250	27	29	25	26	6
						5,500	27	29	26	28	9
						5,750	27	29	27	28	13
						6,000	27	29	27	29	16
						6,250	27	30	27	29	19
						6,500	27	30	28	30	22
						6,750	27	30	28	30	24
						7,000	27	30	28	30	26
						7,250	27	30	28	30	27
						7,500	27	30	29	30	28
						7,750	27	30	29	31	28
						8,000	27	30	29	31	29
						8,250	28	30	29	31	29
						8,500	28	30	29	31	29
						8,750	28	30	29	31	30
						9,000	28	30	29	31	30
						9,250	28	30	29	31	30
						9,500	28	31	29	31	30
						9,750	28	31	29	31	30
						10,000	28	31	30	31	30
						10,000	28	31	30	31	30

^aWhen 800 taf < PMI.

Note: Number of days when maximum daily average EC 2.64 mS/cm must be maintained. (This can also be met with maximum 14-day running average EC of 2.64 mS/cm, or 3-day running average Delta outflows of 11,400 cfs and 29,200 cfs, respectively.) Port Chicago standard is triggered only when the 14-day average EC for the last day of the previous month is 2.64 mS/cm or less. PMI is previous month's SRI. If salinity/flow objectives are met for a greater number of days than required for any month, the excess days shall be applied towards the following month's requirement. The number of days or values of the PMI between those specified below shall be determined by linear interpolation.

Table 5-3. Determination of Habitat Protection Compliance during 1999

Month	PMI ^a	Compliance		Days Met	Carryover Days ^b	Criteria Used to Meet Objective ^c
		Location	Required Days			
Feb	2.60	Port Chicago	23	31	8	3-dm of NDOI>29,200 cfs daily mean of EC 14-day mean of EC
Mar	4.59	Port Chicago	28	31 22 18	3 0 0	3-dm of NDOI>29,200 cfs daily mean of EC 14-day mean of EC
Apr	3.67	Port Chicago	17	29 9 N.R.	12 0	3-dm of NDOI>29,200 cfs daily mean of EC 14-day mean of EC
May	3.26	Port Chicago	6	7 2 N.R.	1	3-dm of NDOI>29,200 cfs daily mean of EC 14-day mean of EC
Jun	4.27	Chippis Island	25	21 28 30	0 3 5	3-dm of NDOI>11,400 cfs daily mean of EC 14-day mean of EC

^aPMI - Previous month's Eight River Index in maf.

^bCarryover days may be used to meet the next month's requirement, if at the same compliance location.

^cCompliance may be met using either daily EC, 14-dm EC <2.64 mS/cm or specific 3-dm of NDOI.

In 1995, SWRCB WR 95-06 eliminated the Chippis Island running 28-day salinity average standard and the Eastern Marsh standard at Mallard. WR 95-06 added a new narrative objective for the brackish tidal marshes of Suisun Bay to protect remnant tidal marshes and changed the compliance date for two western Suisun Marsh stations, S-35 and S-97, to October 1997. SWRCB granted extensions three times, pushing the compliance requirement to November 1, 1999. SWRCB's D-1641, adopted on December 29, 1999, converted these two western marsh stations to monitoring stations, dropping the compliance requirements at both locations.

The Suisun Marsh Salinity Control Gates first began operation in 1989 and operated as needed during the eleventh control season (from October 1 to May 31). The gates, located 2 miles downstream from Collinsville in Montezuma Slough, respond to daily tidal fluctuations, opening to admit fresher flow from the Sacramento River and closing to block tidal salt-

water intrusion from Suisun Bay. The control gates are considered to be in full operation when all three are tidally operated, the flashboards have closed off the channel, and the boat lock is operational.

These gates are operated to meet the Bay-Delta Plan objectives for salinity. During water year 1999, they were only operated for the purpose of conducting a special study to evaluate the effects of modifying them on the passage of adult Chinook salmon — from October 1 through October 12, and from October 27 through November 12, 1999. Marsh conditions were relatively fresh during the first half of 1999, making it unnecessary to operate the gates during the balance of the eleventh control season, although modified flashboards remained in place through April 6, 1999.

The gates were closed for several hours on February 3, 1999, to conduct a current velocity test through the modified flashboards. The test was conducted to determine a relationship between

velocity and stage under tidal flow conditions through the modified flashboards for the purposes of modeling and fish passage analysis.

From September 1 to November 9, 1999, operation of the salinity control gates was specifically geared to satisfy the needs of the adult salmon passage study. After the completion of the study, the gates were operated from November 10 to December 31, 1999, to meet salinity standards despite the SWRCB's waiver of the standards during the 3-year fish passage study (Table 5-4).

Bay-Delta Plan Brackish Tidal Marshes of Suisun Bay Narrative

The Bay-Delta Plan's narrative water quality objective for brackish tidal marsh protection is stated as:

Water quality sufficient to support a natural gradient on species composition and

wildlife habitat characteristic of a brackish marsh throughout all elevations of the tidal marshes bordering Suisun Bay shall be maintained. Water quality conditions shall be maintained so that none of the following occurs: (a) loss of diversity; (b) conversion of brackish marsh to salt marsh; (c) for animals, decreased population abundance of those species vulnerable to increased mortality and loss of habitat from increased water salinity; or (d) for plants, significant reduction in stature or percent cover from increased water or soil salinity or other water quality parameters.

SWRCB determined, through modeling studies, that implementation of Bay-Delta Plan numeric objectives, particularly NDOI, would achieve the narrative objective. In the future, the Department and the Bureau will review and replace the narrative objective with Suisun Marsh Ecological Workgroup recommendations. During 1999, SEW focused on completing its final report to SWRCB. The report is to be submitted in January 2002.

Table 5-4. Amended D-1485 Suisun Marsh Salinity Standards in Effect during 1999

Month	Standard MHTEC	Actual MHTEC ^a				
		C-2 Collinsville	S-64 National Steel	S-49 Beldons Landing	S-21 Sunrise Club	S-42 Volanti
Eleventh Control Season						
January	12.5	0.4	0.9	2.7	3.1	3.3
February	8.0	0.1	0.4	1.0	1.0	1.4
March	8.0	0.2	0.3	0.7	1.0	1.0
April	11.0	0.2	0.4	1.1	1.2	1.2
May	11.0	0.2	0.6	1.2	1.5	1.5
Twelfth Control Season						
October	19.0	9.0	7.7	10.6	13.6	12.0
November	15.5	8.7	8.5	11.3	13.9	12.6
December	15.5	7.2	7.8	10.3	12.7	11.6

^aMHTEC - Monthly average of both daily high-tide ECs in mS/cm.

Note: Additional stations S-35 and S-97 not in effect because of SWRCB variance issued as part of WSCT.

Western Delta Municipal and Industrial Users Agreements

Several contract water quality standards are in effect for western Delta municipal and industrial water users that predate D-1485 and subsequent water rights decisions and plans. Under agreements with both municipal and industrial contractors, loss of offshore water is compensated for by substitute water supplies, net credit balances for days of above-average water, or monetary payment.

The Department contracted with the Contra Costa Water District in 1967 and with the City of

Antioch in 1968 to ensure that Contra Costa and the City would be compensated for costs associated with the loss of usable offshore Delta water supplies as a result of SWP operations.

Credit for the number of days of above-average offshore water supplies of usable water quality is accrued to offset the number of below-average days in future years. Contra Costa's standard is 142 days and Antioch's is 208 days of usable water, respectively. During the 1998-99 water year, a usable Delta water supply was available to Contra Costa and the City of Antioch throughout the period of standard and no compensation payments were made.



Delta levee maintenance in the Suisun Marsh. Much of the land in the Delta is below sea level and relies on more than 1,000 miles of levees for protection against flooding.

6. Other Delta and SWP Reports

These additional reports, relating to 1999 operations, document Delta fish and wildlife studies; water quality conditions; water supply operations; and monitoring research. Some are published regularly and others are special 1-time publications. Consult Bulletin 170-99 for a listing of Departmental publications.

- (1) *State Water Project Operations Data Report*
Division of Operations and Maintenance's
State Water Project Operations Control
Office

This report provides a monthly summary of operations data for the SWP and has been published monthly since 1965. It provides the State Water Contractors, public agencies, and others with the daily and monthly status of the SWP's water and power operations. An electronic version is available at <http://www.woco.water.ca.gov>.

- (2) *State Water Project Annual Report of Operations 1995*, April 1999

Division of Operations and Maintenance's
State Water Project Operations Control
Office

This annual report summarizes the water and energy operation of the SWP. It includes historical data, summarizes the operation of SWP facilities during 1995, and includes any revision to data previously mentioned in the monthly report, *State Water Project Operations Data*.

- (3) *Bulletin 120-99, Water Conditions in California*, (Reports 1 through 4)

This bulletin provides precipitation, snow-pack, and reservoir storage data throughout the State. It is published by the Division of Flood Management and issued as a set of four monthly reports (February through May). It is electronically accessible at cdec.water.ca.gov/snow/bulletin120.

- (4) *Water Quality Assessment of the State Water Project, 1996-1997*, September 1999

Division of Operations and Maintenance

This report discusses water quality trends in the SWP in 1996 and 1997. Higher than normal runoff in 1996 caused higher mineral levels in the SWP, and saltwater intrusion increased salinity in the Delta toward the end of 1997.

- (5) *Methodology For Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh*, June 1999

Office of State Water Project Planning Delta
Modeling Section

This is the 20th annual progress report of the Departments' San Francisco Bay-Delta Evaluation Program documenting the development and enhancement of Delta computer modeling efforts and reporting the latest findings of studies conducted.

- (6) *Bulletin 132-97, Management of the California State Water Project*, June 1999

Bulletin 132-97 updates water supply planning, construction, financing, management, and operation of the SWP. It discusses water supply and delivery, Coastal Branch Phase II, implementation of the Monterey Agreement, and Delta planning activities.

- (7) *Bulletin 132-98, Management of the California State Water Project*, November 1999

Bulletin 132-98 updates water supply planning, construction, financing, management, and operation of the SWP. This bulletin reports the progress of planning studies for future water and power supplies, construction projects, litigation, financing and future costs, the Monterey Agreement, the Bay-Delta Accord, and other areas of interest.

The Department has participated in cooperative studies with other State and federal agencies and universities under the Interagency Ecological Program for the Sacramento-San Joaquin Estuary since 1971. The following reports were published by the Department's Environmental Services Office in 1999 and represent the results of scientific monitoring and field studies conducted in the Delta.

- (1) *Interagency Ecological Program for the Sacramento-San Joaquin Estuary. IEP Newsletter*, Volume 12, Number 1-4, 1999

This multi-agency program newsletter reports the results of Delta water quality and fisheries projects, Suisun Marsh activities, and other scientific activities undertaken by the IEP member agencies, usually released as numbered technical reports.

- (2) *Water Quality Conditions in the Sacramento-San Joaquin Delta During 1995*

The SWP is operated in accordance with SWRCB D-1485 and the 1995 Bay-Delta Plan. This report summarizes 1995 water quality data from the Sacramento-San Joaquin Delta.

- (3) *Effects of the Central Valley Project and State Water Project Operations from October 1998 through March 2000 on Steelhead and Spring-run Chinook Salmon*, February 1999

This biological assessment was written by the Department and the Bureau for the U.S. Fish and Wildlife Service. The report was printed by the Bureau. The report discusses the effects of CVP and SWP on Central Valley steelhead trout and spring-run Chinook salmon.

Interagency Ecological Program Technical Reports

Technical Report No. 63: *Report on the 1980-1995 Fish, Shrimp, and Sampling in the San Francisco Estuary*, November 1999